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Chapter 11

Sustainability in architectural regeneration

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INTRODUCTION

The term sustainability has been defined in many ways, discussed and criticised as a term that lacks clarity, but if the debate is put aside, the key concepts underlying the term are clear. Sustainability is about sustaining life in the long term and sustaining the life-support mechanisms that humans and other species rely on for survival.

From a built environment perspective, designing for sustainability is equivalent to designing for longevity. This includes longevity of buildings, which need to be viable in the long term and resilient to the stresses of changing climates, and the longevity of ecosystems and natural life-support mechanisms. To achieve the latter requires a reduction of the anthropogenic impacts on these systems, and this is a fundamental aim of sustainability. Another fundamental aim is to achieve a high quality of life and wellbeing for people. Not only it is undesirable and could be described as unethical to aim for a lifestyle that lacks quality overall or where quality of life is unevenly distributed between individuals and communities, but longevity and quality are interdependent. From a built environment point of view, high quality environments are typically viable in the long term. Furthermore, to reduce the anthropogenic impacts on the environment, people will have to change their lifestyles. To motivate individuals to adopt sustainable lifestyles, the new sustainable lifestyle has to offer a high quality life if not a higher quality life than the previous one. Therefore, to create sustainable built environments it is essential to create high quality, socially, culturally and economically long-term viable developments that have minimal impact on the environment.

Sustainability is multi-dimensional with technical, socio-economic, environmental, political and ethical implications, some of which can be quantified and others not. For instance, the 'services' provided by natural environments to society, such as purifying water and air, alleviating flooding and more, can be valued in economic terms (United Nations 1992; Girardet 2004; WWF 2014). The value of cultural activities is far more difficult to establish, as is balancing cultural customs and the natural environment when the former negatively impacts on the latter. Personal interests and ethics come into play when prioritising actions in relation to sustainability. However, there is now global consensus that addressing global warming and climate change resulting from greenhouse gas emissions is a global priority (United Nations 2015). The UK government, for example, has set a goal of an 80% reduction in carbon dioxide (CO_2) emissions by 2050 from 1990 levels (UK

Government 2008) in order to keep global warming within the 2°C believed to mitigate risks, impacts and damages (Meinshausen *et al.* 2009). Buildings in the UK account for nearly 47% of total CO_2 emissions in the UK (DBIS 2010) and 40% of energy consumption in Europe (European Union 2010).

Addressing climate change in conjunction with other environmental issues, such as resource depletion, pollution, destruction of biodiversity, as well as human health and well-being, requires technical solutions, many of which exist and are increasingly common. It also requires political and economic implementation mechanisms that, however, are often hampered by the human psychology, which can be characterised as conformist, ultimately self-interested, averse to perceived loss and change, and often subject to short term views (Cialdini 2008; Earls 2009; Kahneman 2012; Pratarelli 2012; Burns 2013; Kottler 2013; Dietz 2015). Sustainability requires a long term view and lifestyle changes, which may not appear attractive to many people and most are yet to become mainstream. As a result, progress towards a more sustainable society remains slow.

The regeneration of buildings and settlements is more acutely affected by the challenges related to selecting and implementing sustainable strategies and solutions than new developments. Apart from the potential technical difficulties of working with existing environments, regeneration affects the socio-economic status of an area and a community. These socio-economic impacts need to be evaluated but accurate predictions can be difficult to make. For instance, the regeneration of a deprived area should create a higher quality of life for residents, but can also negatively impact on local communities who are out-priced once property prices increase. An understanding of the context and the impact that the development might have is essential to make informed decisions.

Therefore, to be sustainable the regeneration of buildings or settlements has to be viable long-term and impact minimally on the natural environment, and this can only be achieved by first understanding the socio-economic and natural context and then developing solutions that respect it. Solutions have to be evaluated in terms of impacts (what is gained and lost) and feasibility (what is possible and what resources are needed to achieve the strategy). Designing for low carbon emissions throughout a development's lifetime is a key priority, but other sustainability issues cannot be ignored. Nor can the human dimension that is pivotal in the implementation of sustainability.

SUSTAINABILITY AND THE BUILT ENVIRONMENT – A FRAMEWORK FOR ARCHITECTURAL REGENERATION

The built environment influences the way people live and can consequently influence how sustainably they live. It creates a framework for living and can be configured to support sustainable living through interventions in the urban and built environment. The built environment has evident limitations of influence and the most pro-environmental behaviour context can fail to have any effect on certain individuals. Furthermore, some aspects of sustainability, such as excessive consumerism, simply cannot be addressed at a built environment level. Despite these limitations, the multifaceted nature of the built environment provides many opportunities for creating a more sustainable environment that supports sustainable lifestyles.

A useful tool to examine the beneficial potential of interventions is the Ecological Footprint. The Ecological Footprint was developed by Rees and Wackernagel in the early 1990s as a measure of the Earth's carrying capacity in relation to human activity (Chambers 2000). The World Wildlife Fund, WWF notes that

> [o]ur Ecological Footprint – which measures the area (in hectares) required to supply the ecological goods and services we use – out strips our biocapacity – the land actually available to provide these goods and services.
>
> (WWF 2014: 32)

In most European countries as well as many other countries worldwide, the carbon footprint constitutes more than half the total ecological footprint (WWF 2014), supporting the global view that reducing carbon emissions is the most pressing challenge. Ecological footprinting can be used to assess the impact of lifestyles, as well as the impact of any activity. Personal lifestyle ecological footprint assessments distinguish between the impacts associated with the food consumed, shelter/ buildings, mobility and consumer goods and waste production. There is an additional footprint component associated with services provided nationally and apportioned to the individual. Depending on personal habits and the individual's location the impacts associated with these four categories vary.

The regeneration of the built environment can help to a very limited degree to address the impacts associated with food, by, for instance, integrating food production within cities and on buildings, and facilitating the sale of local food by creating spaces to host local food sales, such as farmers markets. Such interventions are not sufficient to provide locally produced food for all but can help to reduce food miles, reduce packaging, encourage the local agricultural economy and educate the community in methods of growing food and the importance of sustainable food production, which may in turn raise awareness of other aspects of sustainable lifestyles. The Incredible Edible movement (www.incredibleedible.org.uk) shows what can be achieved in existing urban settings and can be an inspiration for urban regeneration projects.

The impact of the built environment on the consumption of goods is mainly limited to such building-related items as appliances. But it could be argued that if the built environment were to provide spaces for leisure and social interaction that support human wellbeing, environments that engender pride, support group and individual identities and generate a sense of ownership and community, it may help reduce the need for consumerism as a leisure activity and status symbol.

The most significant contribution that the regeneration of the built environment can make to reduce an individual's ecological footprint is by addressing the shelter and mobility aspects of an individual's life. These two ecological footprint elements have a significant impact on global warming through carbon dioxide emissions generated by burning of fossil fuels to generate energy. While in Europe the energy use in the buildings sector is decreasing, transport accounts for 29% of carbon emissions and is the one sector in Europe where emissions are increasing (Dings 2010).

Reducing transport energy use and carbon emissions can be achieved mainly at an urban scale, which offers opportunities for integrating features that support reduction in car use and therefore individuals' mobility footprint. These include: the inclusion of cycling paths and pedestrian ways and the configuration of the urban structure to ensure distances between facilities are walkable; the provision of mixed use developments that combine living, working and basic facilities and avoid the need to travel; the creation of high density settlements that support public transport services; and the inclusion of local leisure and community facilities to ensure a community becomes a destination rather than a place from which to escape. Many European cities have historic centres that encompass all these characteristics. In addition, some have public transport systems and policies that limit the use of motor vehicles through the introduction of Low Emission Zones (Green Zones 2018), which help reduce pollution and noise and create more people (as opposed to car)-friendly environments. Buildings can also contribute, but to a lesser extent, by making non-polluting transport means more acceptable by, for instance through the provision of showers and secure cycle storage spaces in places of work.

The ecological footprint can be reduced by applying sustainability strategies to buildings. Good practice can optimise resource efficiency (land, energy, water, and materials) during the regeneration and operational phases of a building; minimise pollution and waste generation, including at the end of a building's life; and reduce other environmental impacts, such as ecological degradation of natural environments that puts biodiversity at risk. Architectural regeneration offers significant potential in reducing land use, material use, waste generation and on-site impacts by retaining and reusing existing buildings and urban centres, many of which are models of compact developments encompassing sustainable land use and avoiding urban sprawl. Existing buildings are often designed with materials that are more easily taken apart, such as brickwork set in lime mortar, which makes them more adaptable and the materials easier to reuse, thus reducing waste. Reusing materials and buildings also reduces a development's embodied energy, which is the energy required to resource, manufacture and install the materials and building components.

While architectural regeneration has some inherent sustainability advantages, working with existing structures also presents challenges. For instance, providing sustainable drainage that avoids the use of the mains sewer system may prove costly or impossible within an established urban context. The major challenge for building regeneration is reducing their operational energy, which is often significantly higher than today's optimal standards such as the Passivhaus standard (Feist *et al.* 2001) or the Active House standard (Active House Alliance 2013). The aim for any sustainable building is to provide good thermal comfort, indoor air quality, lighting and acoustic environments with minimal energy use and carbon emissions over the whole lifetime of the building. Minimising the embodied energy and low carbon strategies for building operation include:

- optimising the building fabric design to minimise the use of energy for achieving thermally comfortable spaces;
- reducing energy associated with auxiliary systems and equipment; and
- installing appropriate renewable energy and low carbon systems of energy generation.

Policies for energy efficiency for new buildings are becoming more demanding, for instance the European Directive (European Union 2010) requires all new buildings to be nearly zero-energy by the end of 2020. Some programmes for upgrading the existing building stocks to improve energy performance are also in place, for instance in Germany where policies, incentives and guidance have achieved savings of 5.7 megatons of greenhouse gas emissions and more than one billion Euros in heating costs between 2006-2011 (Tower Renewal Partnership 2016). Guidance and energy performance targets from the German Passivhaus Standard, which until recently focused on new build, are now also available for energy upgrades to existing buildings. The standard requires a maximum heating demand of 25kWh/m^{2}an for upgrades to existing buildings (15kWh/m^{2}an for new build) or alternatively compliance with building element performance requirements, and a maximum total building energy demand of 60kWh/m^{2}an. The Passivhaus also provides practical guidance on how to achieve the targets, including the provision of U-values of 0.15W/m^{2}K for external wall insulation applied to existing buildings, indicating what constitutes a well insulated building in cold and temperate climates (Passive House Institute 2016). The Passivhaus Standard also advocates the use of mechanical ventilation with heat recovery (MVHR). However, good sustainable design considers the climatic context carefully and in many climates optimal insulation combined with other key principles of low energy design, including natural ventilation, can provide low energy needs and thermally comfortable environments with good indoor air quality without mechanical systems.

The ecological footprint measures the negative impacts on the planet, but sustainable design solutions also aim to be regenerative and make a positive contribution. For example, a positive impact on biodiversity can be achieved by creating protected and appropriate areas to support and enhance biodiversity.

Theoretical strategies will remain theory unless implemented in a way that is acceptable to the users. For instance, to encourage people to leave their cars at home or not even own a car, walkways and cycle paths have to be safe, convenient, pleasant places to use and the distance from the home or workspace to the facility not too far. If a sustainable intervention is not appealing, it will not be used. If a built environment intervention negatively impacts on, or falls short of the expected quality of life, it will sooner or later be rejected. Disliked buildings become obsolete, abandoned and possibly demolished, effectively resulting in a waste of resources. So while the ecological footprint provides a comprehensive method of identifying and measuring the environmental impacts, a successful implementation of sustainable strategies relies on less quantifiable characteristics such as those that support human health and well-being, quality of life, community cohesion, and social equity and inclusion.

The topics outlined above form a framework (Table 11.1) for assessing design strategies. Particularly important when considering regeneration projects is the existing context affected by the regeneration. A sound basis for decision-making can be gained by researching:

- the natural environment, including the climate, and its impact on the energy use of buildings and energy generation as well as the status of the local biodiversity;
- the existing transport facilities and opportunities and barriers to integrating low carbon transport options;
- the built environment including its energy performance;
- the economic status of the development context and potential for long term viable economic strategies; and
- the quality of life opportunities for local community.[1]

[INSERT TABLE 11.1 HERE - keep table on one page]

In addition to desk top and site studies to inform the development brief, consultations with stakeholder communities can inform the socio-economic aspects of the development and can be the beginning of a long-lasting relationship between stakeholders and the development, whereby the stakeholders become the development guardians.

The comprehensive contextual study can inform the development brief in terms of what to include and the scale of intervention (building or urban). For instance, the need for specific facilities may be identified through the socio-economic aspects of the study, while the potential for sustainable energy generation would be identified from the natural environment element. Both the urban and building scale should be considered at all times. The former offers opportunities for addressing transport solutions, efficient use of land resources, and facilities associated with quality of life, such as green spaces and communal facilities; the building scale offers opportunities for energy and other resource efficiency and on-site energy generation; and both scales can offer opportunities for food growing, enhancement and protection of biodiversity, community participation, accessibility for all, developing or enhancing stakeholder identify. Ultimately, the building impacts on the urban context and the urban environment on how the building is used.

REGENERATION: CHALLENGES AND OPPORTUNITIES FOR SUSTAINABLE SOLUTIONS

The relationship between the aims of the regeneration of buildings and settlements and the aims of sustainability can be characterised as synergistic or compatible or conflicting and challenging. Some of the fundamental aims of sustainable development such as the aim for longevity of developments and the aim for economic improvements and providing quality of life for building inhabitants are synergistic with the aims of regeneration. Some aims are compatible, such as the

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[1] Details of a method of contextual research for sustainable developments can be found in Sassi (2016) Built Environment Sustainability and Quality of Life (BESQoL) methodology for development briefs and strategies. In Ed: W. Leal Filho & L. Brandli *Engaging Stakeholders in Education for Sustainable Development at University Level* part of World Sustainability Series. Springer International Publishing.

aim to reuse and repurpose buildings rather than demolishing them. However, while repurposing buildings may be a shared aim, the sustainability imperative to improve the energy performance of buildings, including historic ones, can be in conflict with the aim of preserving and retaining cultural heritage. The latter scenario represents a challenging relationship where the value judgement mentioned in the introduction comes into play. How can a cultural value be measured against the value of contributing towards reducing carbon emissions and global warming? English Heritage's guidance stipulates that

> [u]nderstanding the point at which alteration to the building's character and appearance and performance will become unacceptable depends on understanding the significance of the building and how the building works as an environmental system.
>
> (Pickles, D. and McCaig, I. 2011:4)

The 'significance' of a building or place is a value judgement that is not necessarily universally shared and may be influenced by personal viewpoints. Even when the aims are synergistic or compatible, economic constraints may limit the interventions possible.

Kant's universalisation test stipulates that if an action could be undertaken by everyone without any detrimental results it would be accepted as being ethical (Blackburn 2001). Applied to the question of whether or not to upgrade a house, the following could be considered. According to the Energy Saving Trust (2010) 24 million homes existing today in the UK will still exist by 2050 and will have had to be refurbished to achieve the UK Government (2008) goal set by the Climate Change Act of an 80% reduction in carbon dioxide emissions by 2050 from 1990 levels. Some heritage conservationists have suggested that interventions to buildings with no historic significance could compensate for inaction in relation to upgrading buildings with historic significance (pers. comm.). However, if everyone expected someone else to address global warming, then global warming would not be addressed. The environmentalist point of view is that there are no ethically tenable exceptions.

In practice the world is grey and not black and white as will be discussed below. The consideration of values has to be informed by detailed contextual knowledge and the knowledge of what is technically possible, blanket approaches are not necessarily beneficial. Whether considering architectural regeneration projects that are synergistic or compatible or contrasting with the aims of sustainability, tailor-made solutions are required.

Synergistic Aims of Regeneration and Sustainability

A good example of synergistic aims of regeneration and sustainability is the regeneration of the Fairfield housing estate, in Perth in Scotland. Dating back to 1935, the estate had become crime-ridden contributing two per cent of the crime in Tayside and by 1985, when the regeneration planning began, nearly a quarter of the 450 homes were boarded up.

The regeneration was planned in close consultation with the remaining local residents who expressed their wishes for their community as well as contributed information about the estate and its problems, which ranged from poor street lighting, vandalism, and litter, to the lack of any facility for meeting with other residents, lack of work for young residents, and fear by the elderly residents to leave their homes. The needs identified were evaluated in relation to the physical and economic context including the funding available. Over nearly two decades and eight phases of work, all the retained homes were refurbished with some energy efficient measures, 32 new energy efficient rental homes and 56 homes for sale were built. A new activity centre for the community was also constructed and included IT facilities that contributed to raising education levels among the residents and improving the average school-leaving age. Front and back gardens and large areas of communal landscaping were also reinstated and new children's play areas introduced. By 2002/03 over two hundred housing applications were received and the 40 houses that had become available were re-let within seven days.

The regeneration was successful because it responded to the local inhabitants' needs and other requirements identified through a careful study of the development context. The prospect of a long life for the 'new' development is the result of the physical solutions, such as the gardens, healthy homes and community building, that respond to real needs, but also to the fact that the management of the development was handed over to the residents, who gained employment as administrators, maintenance, cleaning and gardening staff and now manage and maintain more than 300 dwellings. Most importantly they gained control and ownership of their own new housing cooperative and developed a new feeling of pride for the housing and its surroundings. Creating strong and cohesive communities is as much about addressing quality of life as about providing basic necessities. Once living in a particular community becomes desirable the community's long term viability is ensured.

The regeneration successfully addressed other sustainability issues in addition to the socio-economic improvements made (Figure 11.1). The project included the provision of protected area for wildlife and biodiversity and new green leisure spaces for the community, which enhanced the residents' health and wellbeing and, as speculated above, might have contributed to a move away from a consumerist approach to life. The reinstated gardens offered the opportunity to grow food locally with a potential to reduce the residents' food ecological footprint. As the estate is located only one mile from the city centre of Perth with a local bus service, car dependence was low and the paths near the green spaces were turned into safe cycle ways, which helped the residents reduce their travel ecological footprint. The existing buildings were upgraded further reducing the inhabitants' ecological footprint. The energy efficient solutions implemented were also synergistic with the aim of affordability for the community by creating homes cheap to heat.

The synergistic aims of providing sustainable energy upgrades of the homes to reduce carbon emissions and the regeneration aims to provide good and affordable housing, and the provision of new green spaces for the residents that also benefited wildlife represent an integrative approach.

Such an integrative approach couples the regeneration and sustainability ambitions so that they are mutually reinforced.

[INSERT FIGURES 11.1-11.3]

Compatible Aims of Regeneration and Sustainability

Less mutually supportive and more mutually tolerant were the regeneration and sustainability aims for the Eastern Village Cohousing in Washington DC in the US. Eastern Village Cohousing describes itself as an intentional urban community committed to inclusive decision-making through consensus that supports diversity, nurtures the group's interrelationships, engages with the outside world responsibly, and aims for sustainable design and a balance between aesthetics and affordability. The development of the cohousing involved the regeneration of a disused 1957 office building into 56 flats of varying sizes for different income groups, as well as communal facilities including a communal kitchen, living room, exercise room, two play rooms for children of different age groups and three guest rooms (Figures 11.4 and 11.5). What was once a car park is now a green courtyard with seating and a children's play area. By virtue of its location car ownership is not essential and car parking is not provided, while cycle storage is. The roof of the block is accessible to all the residents who use it as a social meeting space. The block incorporates ground source heating and cooling (with a payback of four years), renewable materials and non-toxic finishes. The building fabric might have benefitted from more ambitious energy saving targets but the design already cost twenty percent more than conventional building and affordability was an aim for the regeneration. The regeneration of the building also had a positive impact on the neighbourhood, which benefited from a disused building being put back into use and the increased footfall of new residents.

For some of the residents the driving force to embark on or join the cohousing was the wish for a new and more meaningful way of life, whether being able to work less and spend time with children or being less isolated in retirement. This social dimension created a solid basis of a long life for the development.

The regeneration could have taken place without the sustainability improvements, but it presented an opportunity to implement sustainable building strategies without affecting the overall regeneration aims. The regeneration and sustainability aims in this case were clearly compatible. The barriers to an even more uncompromising sustainable building design were financial and not related to issues of regeneration.

[INSERT FIGURE 11.4 AND 11.5]

[INSERT FIGURE 11.6]

Conflicting and Challenging Aims of Regeneration and Sustainability

A more challenging situation occurs when either the technical solutions to achieve sustainability are in conflict with regeneration aims or when the development budget is very limited and unable to fund sustainable interventions. The initial development of the Vauban area of Freiburg is an example of the latter.

When the French military left Freiburg in 1992 the existing barracks built in 1937/38 represented viable housing for Freiburg's more alternative inhabitants within the context of a city with an undersupply of housing. A group, of mainly students, formed the SUSI initiative (Selbstorganisierte Unabhängige Siedlungsinitiative e.V – Self-organised independent settlement initiative) (SUSI, nd) and following negotiations with the city for the retention of the barracks, were finally granted use of four barracks. By 1998 the four barracks had been converted and the regeneration of the whole military site into an essentially car-free development was under way. Due to severe financial limitations, it was only later in the process that energy efficiency measures could be financed. Initially it was mainly lifestyle choices that made a major impact on reducing the inhabitants' ecological footprint rather than building interventions.

The urban context positively supported sustainable lifestyles by providing a new affordable tram link to the city centre and safe cycling paths around the city. Local facilities included opportunities for buying locally produced food and other necessities obviating the need to travel to shops. However, lifestyle choices have a limit in their ability to reduce ecological footprints in a climate where winter temperatures range between 0-6 °C. While the barracks were only minimally heated, their solid masonry construction made them energy intensive to heat and ultimately unsustainable. A building level intervention was essential and eventually the existing structures were externally insulated. The original external finish was render and as render was applied over the insulation the character of the building was minimally affected.

Twenty-five years later, in addition to the refurbished barracks, the regeneration of the whole site included super-insulated homes, district heating, pedestrian-friendly paths and ample space for children. Within these unrecognisable surroundings the original four barracks are still occupied and the community strong, not only due to the sustainable physical environment but also due to the legal structures adopted twenty years earlier which ensured perpetual affordability thus addressing a critical social need.

[INSERT FIGURES 11.7-11.9]

Heritage versus sustainable building operation

The regeneration of an area provides an opportunity for upgrading the public realm and building stock. The case studies discussed demonstrate how this can also provide an opportunity for making an area more sustainable in terms of reducing transport and building impacts and improving the social and natural environment context. Considering the imperative of addressing climate change, the fact that buildings are associated with approximately 40% of carbon emissions (DBIS 2010; European Union 2010) and long timeframe of regeneration projects, any building intervention has to be carefully evaluated in relation to its long-term impacts. The external insulation solution at Vauban can provide reductions in energy use in the order of 60-80% (Baeli 2013), which is in line with the Climate Change Act 2008 targets, but this and other solutions may compromise the character of the building or streetscape. How to upgrade buildings of historic or cultural or streetscape value is particularly challenging. In such situations there are perhaps three possible ways forward: providing energy to the buildings from remote renewable sources, prioritising cultural value and potentially failing to address environmental targets, or prioritising environmental issues with the risk of compromising the cultural heritage.

An example of the first option was implemented in the city of Gussing, Austria. In response to an economic crisis in the late 1980, the city, which now has nearly 30,000 inhabitants, began developing their forestry industry to supply the whole city with energy from biomass. Now the city benefits from a facility to convert rapeseed oil into car fuel, a number of decentralised combined heat and power biomass plants providing heat and electricity to the whole city and attracts businesses interested in operating as zero carbon businesses. The city also gained in terms of social sustainability with the creation of new job opportunities and the ability of residents to work locally, which improved their quality of life while further reducing the ecological footprint. Gussing's twelfth-century castle did not have to be altered and retains its original fabric and aesthetics and is a zero carbon building.

Gussing was able to become sustainable by making use of 50% of the surrounding forest growth to run the city. This settlement-wide approach worked because of the particular context comprising a relatively low population density of less than 100 people per square kilometre and ample woodlands. Considering the UK population density is more than three times that of Austria and natural resources such as timber are more limited, a different approach would be needed in a similar size settlement in the UK.

Where settlement-wide approaches are not possible, building solutions have to be evaluated based on quantitative evidence. Like many heating-dominated countries, heating energy in the UK typically constitutes nearly 60% of total energy use in dwellings (Hamilton 2013). The exact amount will depend on the building configuration (for example the area of external fabric), fabric design (the levels of insulation and air-tightness of walls, roof, floors, windows and doors) and the building services (mainly the efficiency of the boiler and ventilation system).

Building services solutions may be possible if sufficient land is available. For instance, Historic England (2017) guidance on the use of heat pumps illustrates a smaller scale solution applicable to buildings with sufficient land available to install ground source heat pumps and other renewable energy sources to run the heat pump. Vertical heat pumps can be installed where available land is limited but if renewable energy sources cannot be installed to run the heat pump, then the resulting carbon emissions are similar to those of efficient gas boilers. Improving the energy performance of the building fabric is therefore sometimes necessary and requires understanding the potential benefits of different interventions.

Building fabric upgrades should be informed by computer modelling that can account for the different variables of a building, such as the area of external wall that varies between single and multi-storey building, detached and terraced properties and so forth. Rules of thumb can be misleading and where regeneration funds are limited, a quantified analysis will help identify the most cost-effective and impactful intervention. Research does provide some indication of the effectiveness of different building interventions. For instance, research by Gillott et al. (2016) shows that minor reductions in heating energy use up to 9% can be achieved by the comprehensive draught proofing of floors, ceilings, floor-ceiling junctions, around openings including window, doors and pipes and installing lock covers. These are interventions that generally don't affect the character of buildings, but have limited impact. The researchers identified more significant reductions from cavity wall insulation and double glazing (40%) and new boilers and ventilation system (35%). Roofs can be associated with as much as 25% of heat loss (Curtis 2008), but this figure will vary according to the height of the building. Furthermore, the worse performing buildings can achieve the most significant percentage improvements, for example, externally insulating solid masonry walls, which make up a third of the UK building stock and are the least insulated wall type, can reduce heating energy use by 45% (NIA n.d.). These results have to be used with care as regeneration is subject to many contextual variables not least the users of buildings, as shown by the study by Hong et al. (2006) of the impact of insulating the building fabric in low income dwellings. The insulation of these often modestly heated spaces made the spaces more comfortable rather than resulting in a significant reduction in energy use.

Keeping in mind the aim to reduce carbon emissions by 2050 to 80% from 1990 levels (UK Government, 2008), the Energy Saving Trust examined what combination of interventions would achieve 60% (EST 2008) and 80% (EST 2010) energy reductions and established that both fabric and services performance improvements are required to achieve these targets. In summary, insulation to walls, floors, ceilings, windows and doors is required as well as making the buildings more airtight and upgrading heating systems. All the interventions, not one or the other, are required to achieve the 2050 targets.

A comprehensive approach, albeit without performance targets, is also advocated by Historic England (previously English Heritage) that recommends 'the performance of the whole building in its context must be assessed with regard to heating, ventilation, insulation and energy efficiency' (Pickles and McCaig 2017: 22) as well as considering the construction in detail and the spatial configuration of the buildings (Pickles and McCaig 2017). As with guidance provided by The

Society for the Protection of Ancient Buildings and Historic Scotland (Curtis 2008; Mallion 2014) the focus is on developing solutions that don't damage the fabric and character of the building. These organisations also provide technical guidance in relation to energy upgrades and two interrelated issues are of particular concern: 1) the levels and position of insulation and 2) the moisture in buildings and condensation within and on the surface of the building fabric.

Preventing condensation requires a careful selection of materials and the preference of hygroscopic and vapour permeable materials and the avoidance of cold spots from thermal bridges (Héberlé and Burgholzer 2016; Pickles and McCaig 2017; Engel Purcell 2018). Whether the insulation is located on the inside of a wall, in a cavity or externally has an impact on the potential interstitial condensation. Internal insulation means the original wall is exposed to external temperatures and forms a cold surface on the exterior face of the internal insulation where condensation can occur. The risk rises with increasing insulation thickness, which results in an equally increasingly cold external original wall. External insulation avoids this problem and other cold bridges from, for example floor joists, but external insulation has to be vapour permeable so as not to trap moisture in the building fabric where it could condense (Mallion 2014).

When upgrading a building in line with government set carbon emissions reduction targets of 80%, the insulation needs to provide fabric U-values of 0.1-0.2 W/m^2K, which for vapour permeable insulation (e.g. timber fibre insulation) can be achieved with an insulation thickness of 200-400mm. Existing attics provide ample space for such thickness of insulation, but eaves details have to be developed to avoid cold bridges. Existing wall cavities are too thin to accommodate 200-400mm insulation, but cavities of new walls can be made wide enough. External insulation can accommodate such thicknesses but impacts on the facade design and the character of the building. In the UK Feilden Clegg Bradley Studios, Prewett Bizley Architects (Baeli 2013), and Sassi Chamberlain Architects are just a few of the architects who have achieved in the order of 70-80% heating energy reductions by applying a combination of external and internal insulation and new highly insulted wall or roof elements (Figure 11.10-11.13).

[INSERT FIGURES 11.10-11.13]

In France, Germany (Polgar 2006; Passivhaus-Datenbank n.d.) and Italy (Dalla Mora *et al.* 2015) insulated panels and elements have been used to insulate buildings externally in historic centres and even used to replicate the original facade details, such as shaped cills or cornices, thus retaining the character of the buildings and street. This does, however, pose a question about authenticity and the value of authenticity, but demonstrates what is possible when the priority is of maintaining the existing fabric seemingly untouched.

Solutions are needed that provide a balance between improved performance and retention of historic value. While Historic England acknowledges that ‘very few historic buildings or places survive as originally built’ (2017: 17) it is also suggested that understanding and developing solutions for historic buildings requires ‘the knowledge, skill and judgement of a qualified and experienced professional advisor such as an architect or surveyor experienced with historic buildings’ (Pickles *et al.* 2011: 4). However, these specialists do not necessarily have the knowledge, skill and judgement in relation to sustainable solutions and may not be aware that a piecemeal approach to upgrading historic buildings is not going to achieve the target of 80% carbon emission reductions, as Rich also recounts in chapter 12. A study by the Grantham Research Institute suggests that energy performance improvements are significantly less common in Conservation Areas and Listed Buildings due to legal restrictions and cost barriers, and suggests that a relaxation of preservation policies for their study period between 2006-2013 would have resulted in reductions of 8.9 million tonnes of carbon (Hilber *et al.* 2017). It may be time to reconsider the value apportioned to some historic buildings and consider applying the categorical ‘don’t touch’ to buildings that really deserve to be made the exception when the stakes in relation to global warming are so high. More importantly it is time to adopt a more multidisciplinary decision-making approach combining historic building with sustainability expertise.

At this point it is worth reporting an anecdote from Freiburg conveyed to the author when visiting Vauban. The city official was proudly recounting the city’s sustainability history, which over four decades benefitted from the support of many citizens. When it came to installing two large wind turbines in the neighbouring mountains support turned to scepticism and worries about the landscape being destroyed and even tourism suffering. But when the wind turbines were installed, the city official laughed, more visitors were coming to view the turbines than the mountains.

Not all change is negative. The regeneration of cities and buildings is an opportunity for positive and sustainable change. Like the wind turbines in the German mountains, what at first seems threatening can bring positive outcomes.

CONCLUSION

The regeneration of an area happens too seldom to ignore the opportunities it represents to develop sustainable solutions. Sustainability is about context, resources, economics and climate change as in Gussing; it is about supporting people and providing opportunities for a high quality of life, as in Perth; and it is about a holistic approach that encompasses buildings, the urban context, and human behaviour, as in Freiburg.

Making the regeneration process and outcomes sustainable may not always be without challenges. In many cases the aims of regeneration and sustainability are synergistic and compatible but they can be in conflict with one another. These conflicts relate mainly to change, perceived loss of historic character and are fundamentally about values. One point of view might question whether cultural identity can exist without history and the other point of view might question the value of culture at the expense of an environmental disaster. To bridge that gap, technologies are already helping to improve the performance of historic buildings without impacting on their character, as with transparent photovoltaic panels that can remain invisible, aerogel insulation, which has half the conductivity of polyurethane insulation and a quarter that of rockwool, can provide insulation where very little space is available, and even insulating ceramic-based paints are being developed for use in buildings. In addition, a better understanding of the issues discussed in this chapter is needed to address these challenges.

As Frank Trentmann (2016) advocates in the conclusion to his book *Empire of Things*, a new perspective is required that acknowledges that nearly 50% of CO_2 emissions are from UK homes and transport, which are on the whole ignored by the majority of the population that focuses instead on recycling, which he describes as 'little more than a comforting distraction from the things that really matter' (Trentmann 2016: 675). Sustainability requires a new and informed perspective that acknowledges that climate change will not be addressed unless all possible interventions at building, urban and behavioural level are undertaken simultaneously. There are no ethical exceptions. In fact, there is an ethical imperative to seek opportunities, such as the regeneration of a building or neighbourhood, and appropriate information and knowledge to make the built environment more sustainable.

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Captions

Figure 11.1-11.3 Fairfield housing estate refurbished housing and play area (Photographs by Paola Sassi, 2004)

Figure 11.4 and 11.5 View of Eastern Village Cohousing courtyard garden from the roof and from the street entrance (Photographs by Paola Sassi 2013)

Figure 11.6 View of street elevation of Eastern Village Cohousing (Photographs by Paola Sassi, 2013)

Figures 11.7-13.9 Vauban barracks upgraded with external insulation and painted by the occupants and the community (Photographs by Paola Sassi, 2004, 2014)

Figures 11.10-11.13 Victorian terrace before and after a comprehensive performance upgrade by Sassi Chamberlain Architects with internal insulation to the street elevation and external insulation to the private rear elevation (Photographs by Paola Sassi, 2008, 2010, 2012)

Table 11.1 Outline framework for assessing and developing sustainable design strategies