Cost & Value: Multiple Benefits of Green Commercial Buildings in Western Countries

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ABSTRACT

This chapter reviews the cost of green buildings, together with their quantifiable and qualitative added value. It reviews energy costs in relation to other benefits of green building design and retrofit, at building, community and national scales. Where data is available it presents cost benefits and also discusses benefits of a more qualitative nature.

Keywords: *green buildings, energy, cost and value*

1. INTRODUCTION

It is widely accepted that a green and more sustainable building will provide added value to its owners and occupiers, justifying any cost increase incurred in its design and construction. However, it has been difficult to attach an actual financial value to the benefits of green buildings, to assess whether they are more attractive to tenants and occupiers, and, the extent to which they attract a financial premium in terms of any increased rental and sales value. Generally, the main recognized quantifiable return on an investment in green design has been the energy savings, and even this is often uncertain in relation to the finished building, and how its users operate it. However, there is the potential for multiple benefits arising from green buildings, in addition to the actual energy savings. The IEA report, 'Spreading the net: the multiple benefits of energy efficiency improvements', published in 2012 (Ryan and Campbell, 2012), recognizes the wider benefits of 'clean energy' projects, which in addition to being of direct benefit to the individual or organization implementing the project, also has benefits for both national and global economies. However, such 'non-market' and socio-economic benefits are often difficult to quantify. Projects are often assessed by energy professionals, with little experience of how energy efficiency might impact on other non-energy sectors. The report also recognized the "rebound effect", by which non-energy sector benefits may result in the predicted energy savings being less than expected. A report by the US IEA, 'Assessing the Multiple Benefits of Clean Energy' (Environmental Protection Agency, 2011) identified environmental and health benefits, and a broad range of economic benefits, as well as reducing stress on the energy system.

Green buildings using clean energy systems can also enjoy the wider economic and environmental benefits. Although currently not well understood, the potential added value of the total package of benefits can be considerable, and much greater than just the energy savings alone, though there also may be rebound effects as introduced above for clean energy systems in general. For example, a rebound effect through the take up of affordable warmth in houses that are designed or retrofitted to be more efficient to heat, which is a positive benefit.

On a life cycle cost basis, even allowing for any rebound effects, the energy savings alone should typically exceed any additional design and construction cost premiums, within a reasonable payback period. There may be increased costs associated with green buildings, especially retrofitting existing buildings to a greener standard. However, by adopting an integrative holistic design approach, these additional costs can be reduced, to an affordable level, and potentially to a level comparable with standard building costs for new build, and within acceptable budgets for retrofit. In addition to energy savings, operations and maintenance costs have the potential to be reduced, for example, through the use of less complex environmental systems for heating, cooling and ventilation.

Energy costs are generally small in comparison to overall business operating costs, which are usually dominated by staff costs. For commercial buildings, green design can lead to a better quality indoor environment, which can improve worker productivity, and occupant health and well-being. This can result in improved productivity 'bottom line' benefits for businesses. However, in spite of these potential benefits, the improved indoor environmental quality associated with green buildings has not generally been a priority in building design and construction.

Buildings that are not designed with sustainability credentials may in future be considered high risk, which might affect their rental income and future asset value, in turn affecting their return on investment. So, buildings with better sustainability credentials could enjoy increased marketability, and their asset value should increase over time. They should be able to more easily attract tenants and to command higher rents and resale prices, and as a result offer a greater overall yield on investment.

Future trends in building regulations to reduce carbon dioxide emissions have also become a concern to building owners, as regulations place greater emphasis on the existing building stock. Changing tenant requirements and investor risk screening may also affect the value of buildings that do not have green credentials. The indication is that in markets where green is becoming more main-stream, there are emerging 'brown discounts', where buildings that are not green, may rent or sell for less. There is therefore an increasing interest in retrofitting existing buildings. Therefore developing retrofit solutions for different building types, and new investment models to address financing retrofits, are crucial to maintaining a building's future asset value.

In summary, green and more sustainable buildings need not necessarily incur significant additional design and construction costs. Their impact scales up to national and global levels, for example, energy cost savings at building scale will result in reduced carbon dioxide emissions at a global scale. The benefits are both quantitative and qualitative, and in future, developers who do not provide green buildings, will potentially incur an investment risk, and reduced marketability. However, these factors and benefits, although having been identified over the last decade or more, have yet to make a marked penetration into the building construction and operation industry. When assessing the benefits of a green building, the main analysis is still generally based on cost of energy saving measures versus cost of energy savings.

This paper reviews the above cost and value benefits associated with green building design. It is based on a review of some of the emerging findings from research and practice, with the main focus on office buildings and housing. It contributes to the activities of the EU COST T1104 Action, Smart Energy Regions, which is exploring a regional approach to implementing low carbon policy into practice in the built environment.

2. COST AND VALUE

The additional cost of a green building relates to how much money is spent on the building compared to a non-green building. If a 'bolt-on' approach is used, the costs are easily identified in relation to the additional 'bolt-on' items of construction or equipment. Such a 'bolt-on' approach tends to incur relatively higher additional costs compared to a holistic and more integrative design approach, where costs may be reduced. Where a more holistic approach is used, it can be difficult to assess costs precisely, as the additional 'green' technologies used in the building may be offset by reducing costs in other areas. For example, the increased cost of a high performance façade may be offset by reduced costs for heating and cooling equipment. Also, a green feature may also be simultaneously used as a more traditional building element, for example, when a Photo Voltaic (PV) panel over a window can 'double up' as a shading device.

The value of a green building can be related to the overall return on the investment, which may be in quantitative terms, for example, energy saved, or, of a more qualitative nature, such as, improved quality of life, although such qualitative improvements can also result in cost benefits. Assessing payback on investment using a single cost parameter, such as the cost associated with energy savings, does not recognize the total value of a green building in use. Added value aspects might include multiple benefits, such as, for a commercial building: more satisfied occupants; longer tenancies and higher lease rates, reduced absenteeism and an overall higher asset value; future proofed and reduced risk of obsolescence; less need for refurbishment in the future; higher demand from institutional investors and satisfying corporate social responsibilities; and, lower operating and maintenance costs.

There is a growing body of evidence, which identifies increased costs and added value benefits for office buildings. It has been shown that, in general, the costs associated with green offices are often exaggerated, and their added value underplayed. The World Green Building Council's report in 2013 (World Green Building Council, 2013), based on a variety of building types in United States, United Kingdom, Australia, Singapore and Israel, summarised a range of benefits from adopting a green building approach, and stated that, whereas the increased design and construction costs associated with a new green building are perceived to be as high as 29%, the actual cost increases found in practice are less than 12.5%, and sometimes equal to, or even slightly less than, the costs of a standard building. Some ten years earlier Kats, et. al. published a report (Kats G, Leon A, & Adam B, 2003) indicating that the additional costs of a green building were on average (from a sample of 33 buildings) around 2% and this could be repaid ten-fold over a twenty year lifetime through lower energy, water and waste costs, lower environmental and emissions costs, lower operations and maintenance costs, and savings from increased health and productivity. They reported increased productivity and health contributing 70% of the benefits, reduced operations and maintenance 16%, and energy savings 11%.

The increased costs for a green building may therefore often be over-estimated, whilst the additional value-added benefits are not always appreciated, and are generally underestimated, or not considered at all. Johnson Controls (Johnson Controls, 2012) reported a range of value-added benefits that green buildings exhibit, including: increased resale value (2-17%); increased rental rates (5.8-35%); higher occupancy rates (0.9-18%); lower operating expenses (30%); higher net operating income (5.9%); lower capitalization rates (50-55 basis points); and, productivity gains (4.8%).

A study by Davis Langden (Davis Langdon, 2007) has also identified benefits for green building owners including: potential higher occupancy rates; higher future capital value; reduced risk of obsolescence; less need for refurbishment in the future; ability to command higher lease rates; higher demand from institutional investors; lower operating costs; mandatory for government tenants; lower tenant turnover; and, less cost to maintain and operate.

Further studies by RICS (RICS, 2005) identified green building benefits to: be quicker to secure tenants; command higher rents or prices; enjoy lower tenant turn over; cost less to operate and maintain; attract grants, subsidies and other inducements to do with environmental stewardship, increase energy efficiency and lessen greenhouse gas emissions; improve business productivity for occupants, affecting churn, renewals, inducements and fitting out costs; and, benefit occupants to an extent that may even exceed the underlying asset's value.

In 2010 Eichholtz et al (Eichholtz P, Kok N, & Quigley JM, 2010) reported a study of some 10,000 buildings indicating that there was an effective rental premium of around 7%, and selling premium of 16% for green office buildings in the US. Pivo and Fisher (Pivo G and Fisher JD, 2009) found that green buildings had up to 5.9% and 13.5% higher market values, driven by 9.8% lower utility bills, 4.8% higher rents, and 0.9% higher occupancy rates. A study by McGraw-Hill (MacGraw Hill 2013) looked into the payback period for green investments and operating costs. It was found that over a one-year and a five-year period, new green buildings were expected to reduce operating costs by 8% and 15% respectively, and by 9% and 13% for retrofits. The payback times were expected to be eight years for new green buildings and seven years for green retrofits. Building values were expected to increase by 7% and 5%, and asset values by 5% and 4%, for new build and retrofit respectively.

A recent study (Nils Kok and Avis Devine, 2015) showed that improved property performance is strongly correlated to green building certification. The research analysed ten years of financial performance data across a 58 million square feet office portfolio in the USA and Canada, indicating: net effective rents on 3.7 % higher in LEED certified properties, and 9.5% higher with ENERGY STAR certification in the U.S. compared to similar non-certified buildings, and 18.7% higher in Canadian buildings having both LEED and BOMA BEST certification; tenant renewal rates were 5.6% higher in Canadian buildings with BOMA BEST Level 3 certification than in buildings with no BOMA BEST certification; tenant satisfaction scores were 7% higher in Canadian buildings with BOMA BEST level 3 and 4 certification than in non-certified buildings; energy consumption per square foot was 14% lower in U.S. LEED certified properties than in buildings without certification.

However, although there are positive signs that green buildings attract higher value in the US, a study by RICS on London offices was not so positive (Chegut, P, Eichholtz, and N Kok, 2012.), and failed to identify improvements of significance.

The energy savings for new build may be related to three levels (table 1). The first is the level of energy reductions (also relating to carbon dioxide emission reductions) in relation to typical improvements in Building Regulations. In the UK typically there would be 25% carbon dioxide reductions between subsequent upgrades of building regulations, which may be every 4 to 5 years. These are considered relatively easy to achieve in an incremental way. The next level might relate to the best level of energy reductions associated with building environmental assessment methods, such as LEED and BREEAM, which are typically 40 to 50%. Finally savings relating to a PassiveHaus level of performance would be of the order of 75%, the remaining 25% potentially provided by renewables, creating a carbon neutral building. Actual energy use will vary with building type and location, but ballpark average levels (UK) might be 200kWh/m2 per year for housing, and 360kWh/m2 per year for offices, with average energy costs of £12/m2 per year and £25/m2 per year respectively.

Level	% savings	Description
1	25	Building regulation improvements
2	40-50	High LEED BREEAM
3	75	PassiveHaus

Table 1: Levels of energy savings

Retrofiting existing offices can yield similar benefits as new build. A US study (Pacific Northwest National Laboratory, 2011) has identified three levels of approach to office retrofit: (i) commissioning, which can typically achieve up to 25% energy savings. An example from a US study of commissioning projects found that office buildings typically realised 22% energy savings through 'existing building commissioning, with an average simple payback period of 1.1 years (Evan Mills, 2009); (ii) standard retrofit, which can typically produce 25-45% savings with payback period of less than 4 years. Such retrofits generally adopt a cost-effective low risk approach, typically using a package of component-level replacements of existing equipment; (iii) Deep retrofits, which are based on an integrated whole-building approach to energy savings projects. Savings of 45% and higher, with a typical payback period of up to 3 years, are achievable when upgrades to the building envelope are combined with retrofits of lighting and mechanical systems. In order to achieve a good performance for a building in use, it is essential to provide a high level of commissioning, and operations and maintenance. The report identified a range of benefits from improved operations and maintenance, including: energy savings; reduced comfort complaints; equipment that operates adequately until the end of its planned useful life, or beyond; improved indoor environmental quality; safe working conditions for building operating staff. It identified energy costs typically constituting 30% of overall operating costs, leading to a substantially increased net operating income and asset value.

The above discussion has focussed on a green approach to commercial buildings, covering both new build and retrofit. For housing, the increased costs associated with new build together with value added benefits, cover a similar range as for offices. However, whereas a component approach to retrofit can be affordable, though perhaps limited in benefits, 'deep' retrofits are generally currently considered high cost, and difficult to finance. In the UK, homes account for more than 28% of total UK energy use, with related carbon emissions (based on 2009 Figures). In the UK, the rate of new build for housing in a year is around 120,000, of a total housing stock of around 27 million, which is a renewal rate of around 0.5% per year. It is expected that 80% of existing dwellings will still be in use in 2050, so housing retrofit is a major area for saving energy and reducing carbon dioxide emissions. A large demonstration programme of housing retrofit was carried out in the UK between 2010 and 2012. Reported results from this programme (M Baeli, 2013) indicated that energy saving measures from deep retrofit schemes could produce on average around 63% energy reduction with most cases in the range 50% to 85%, and for an average cost of around £77,000, from a range of about £45,000 to £118,000. In addition, for most cases between £42,000 to £100,000 was spent on non-energy saving improvements. Clearly these costs are high in relation to potential payback. However, there are indications that costs can be reduced, and if combined with value-added benefits, can sometimes make deep retrofits financially acceptable. This will be discussed later, with to recent case studies.

3. ENVIRONMENTAL ASSESSMENT METHODS

Green' labels are often used to assess the green credentials of a building. A range of Environmental Assessment Methods are now available to apply to buildings in order to assess their performance during design. They include BREEAM (UK) and LEED (US), and they address a range of design aspects, such as indoor environment, material use, location, etc, as well as energy performance. There have been studies to assess the cost of achieving a high assessment rating and the return on the investment. The cost increase associated with majority of certified green buildings typically ranges from <0% to 4%. Higher levels of certification (such as BREEAM Very Good and LEED Silver/Gold) have been shown to have a cost increase in the range from 0% to 10%. Highest levels, such as BREEAM Excellent and LEED Platinum have increased costs of around 2% to 12.5%.

A review of ENERGY STAR and LEED projects (J Jackson, 2009) has identified rent and occupancy premiums that not only pay for the additional green development costs, but also provide an attractive internal rate of return (IRR) on green investments, for an incremental cost of between 1 and 5%.

David Langdon (Davis Langdon, 2007) has indicated from their research in Australia that the initial impact on construction costs (compared to non-Green projects) is likely to be in the order of 3 – 5% for a 5 Star solution, with a further 5% plus for a 6 Star non-iconic design solutions.

A review of recent studies has found that office buildings with green certifications command between around 2 to 27% higher rents than otherwise comparable buildings (Appraisal Institute and the Institute for Market Transformation, 2013). There are also significantly higher occupancy rates for buildings with green and efficient certifications.

However, the cost of an environmental assessment can be considerable. For some companies, the value is in having the certificate, and not always in the improved performance, so there are sometimes pressures to deliver a high assessment rating level for minimum investment.

4. ORGANISATION COSTS

Green building costs, and in particular related to energy performance, should be looked at in the context of the total organisation costs of a building, especially for commercial and public buildings. Studies have estimated that building construction costs and energy savings are a relative small proportion of total organisation costs. For commercial buildings, staff costs make up the bulk of operational expenses, with over 85% of total workplace costs spent on salaries and benefits, compared to less than 10% on rent, and less than 1% on energy (World Green Building Council, 2013).

Operational costs can greatly exceed design and construction costs over a buildings lifetime. Examples of two whole life-costing studies for offices have been described by Evans (Evans, R, Haryott, R, Haste, N and Jones, A, 1998) and Hughs (Hughes, WP and Ancell, D and Gruneberg, S and Hirst, L, 2004). Evans quotes a ratio of 1:5:200, for design/construction costs to operating costs to business costs, respectively. Hughes, however, questions the validity of this ratio, and suggests a ratio of 1:0.4:12, as being more realistic for commercial buildings. However, this still indicates that business costs, a large proportion of which will be staff salaries, outweigh design, construction and operating costs, which include energy costs (typically 30% of operational costs). Design costs can also be included in this ratio, simplistically as 10% of construction costs. Other studies have suggested that an initial 2% upfront investment for a green building will generate a return ten times higher than the initial investment over the life cycle of the building (Kats G, Leon A, & Adam B, 2003). They report that salary costs (USA) of around $65,000 are roughly ten times higher than operations and maintenance costs, which include energy and rent, energy being only 1% of overall costs.

The above analysis implies that the largest return on investment should arise when green buildings also improve business productivity.

5. PRODUCTIVITY, HEALTH AND QUALITY OF LIFE

The previous section has argued that the benefits of increased productivity for a green building outweigh any energy savings, and by itself justifies increased design and construction costs. So life-cycle assessments based on energy savings alone, only provide a relatively small part of the potential overall value benefits to an organization. David Langdon reported that the Building Commission of Victoria indicated that optimal levels of indoor environmental quality would increase Australian workforces' productivity by as much as 30% (Davis Langdon, 2007).

Therefore a major aim of green building design is to achieve good standards of indoor environment, which can in turn improve worker productivity, and occupant health and well-being. In commercial buildings, sick building syndrome (SBS) has often been associated with spaces that have poor indoor environments, usually associated with air-conditioned offices. As long ago as 1984, the World Health Organization (WHO, 1984) reported that 30% of buildings globally may have indoor environments that contribute to SBS. More recently, Heerwagen (2010) (J. Heerwagen, 2010) reported that up to 20% of workers might be affected. Reducing SBS symptoms can potentially reduce absenteeism, as well as increasing productivity, and creating a more favourable working environment, which in turn can reduce staff churn.

As already discussed, an estimated average increase in productivity for a green building with a good environment is 4.8% (Johnson Controls, 2012), with increases up to 30% suggested in some reports (Davis Langdon 2007). If the cost of an office worker is estimated at around £30,000 per year (UK), a 4.8% improvement in productivity would therefore be equivalent to a value of around £150/m2 of office floorspace per year (roughly assuming 1 person per 10m2). If the average sick leave is about 7.0 days per year, using the same estimated staff costs, and assuming 220 working days per year, the average cost of absenteeism is estimated at around £100/m2 per year. A 10% reduction in absenteeism would benefit the business by around £10/m2 per year. These estimated potential cost benefits totalling some £160/m2 are relatively large compared to typical energy cost savings of typically around £3 (to a maximum £30)/m2 a year.

Loftness et al, (Loftness V, Hartkopf V, Gurtekin B, Hansen, D, Hitchcock R, 2003) presented results from eight case studies linking individual temperature control to productivity gains of up to a 3%; fifteen studies linking improved ventilation with up to 11% gains in productivity; twelve studies linking improved lighting design with up to a 23% gains in productivity; and, thirteen studies linking the access to the natural environment through daylight and operable windows to individual productivity gains of up to an 18%. Lucuik et al, (Lucuik M, Trusty W, Larsson N, and Charette R, 2005) cited 35% less absenteeism in spaces with higher office ventilation rates.

Fisk (W.J. Fisk, 2000) has identified for the USA, potential annual savings through productivity gains are $10 to $30 billion from reduced Sick Building Syndrome symptoms and $20 to $60 billion from direct improvements in worker performance that are unrelated to health.

However, although the benefits of a good environment on staff moral and productivity seem obvious, improved indoor environmental quality has not generally been a priority in building design and construction.

6. FUTURE PROOFING

Both businesses and householders are becoming increasingly concerned of the future energy performance of their property. Energy costs, though often considered relatively small for the majority of businesses and households, are rising significantly. Also, security of energy supply may become an issue in future. Energy related building regulations are expanding to consider existing as well as new build. The value of a building in future may therefore be affected by its energy performance, carbon dioxide emissions, and its indoor environmental quality. These may affect the rental income, resale value, and the future overall value of real estate assets, in turn affecting their return on investment.

There may also be affects of extreme weather events and changes in weather patterns that might affect future insurance costs, in relation to a building's resilience. As building buyers, tenants and investors, begin to understand these risks, non-green buildings may become obsolescent. Green buildings may be considered a lower risk, which could result in a higher yield on investment. Interest rates on building related loans may be less for green buildings, reflecting their reduced risk. A green building, whether new or retrofit, can therefore future-proof against these potential cost liabilities.

A positive stance towards environmental issues may in future impact on supply chain acceptance. A company's 'green' real estate can demonstrate a visible signal of the adoption of an environmental policy. It may even contribute to a firm's success in attracting and retaining high-quality employees.

7. CORPORATE RESPONSIBILITY

Carroll's pyramid of Corporate Social Responsibility (Carroll, AB, 1991) for a business includes ethical and philanthropic responsibilities, alongside economic and legal responsibilities. The economic and legal responsibilities relate mainly to its shareholders, owners, and employees. The ethical and philanthropic level responsibilities relate mainly to public interest, which includes the environment.

Green buildings can form a major part of a company's Corporate Social Responsibility Strategy. They have many tangible benefits to a company, as discussed in previous sections, together with the less tangible benefits that can contribute to a favorable corporate reputation. A company therefore may be inclined to choose a green building in comparison to a standard building, to enhance its environmental credentials. A green building can therefore meet both social responsibilities whilst achieving cost savings and other 'quality of life' and economic benefits.

8. MARKETABILITY

There are many reports that relate to the added value of green buildings. Generally they support the argument that buildings with better sustainability credentials enjoy increased marketability. Green buildings are able to more easily attract tenants and to command higher rents and prices. In markets where green has become more main-stream, there are indications of emerging 'brown discounts', where buildings that are not green may rent or sell for less.

The World Green Building Council's report (World Green Building Council, 2013) focusing on commercial buildings, explained that green buildings have a higher asset value, as evidenced by higher sale prices, with higher rental/lease rates, lower operating expenses, higher occupancy rates and lower yields (leading to a higher transaction price). They can be quicker to secure tenants, command higher prices enjoy lower tenant turnover, cost less to operate.

However, as discussed above, there are some barriers relating to understanding the benefits of green buildings, including, the assumption that it costs more to build green, the fact that green strategies are not widely understood, construction companies lack experience, there is a lack of awareness of the market, a shortage of engineers with experience of operating green building systems, a lack of incentives for owner-investors as opposed to owner-occupants. There is also a perceived lack of evidence between lower energy costs for building occupiers, and the benefit to the landlord. Leases do not generally take account of green issues. However green leases can provide benefits to both tenants and landlords (Langley, Hopkinson, Stevenson, 2008). The tenant will benefit from reduced energy bills and improved indoor environments, whilst the landlord can benefit from longer lease periods, a more stable tenant base, and a higher asset value on their estate.

9. FUEL POVERTY AND HEALTH

The 'rebound' effect introduced above (Ryan and Campbell, 2012) may occur when energy savings are not fully realised due to other benefits. One such benefit is affordable warmth in fuel poor housing. Fuel poverty is defined as when a household pays more than10% of its annual income on energy, and extreme fuel poverty is when they pay more than 20% of annual income on energy. In some countries this is becoming of epidemic proportions. For example, up to 25% of UK households, and up to 33% in Wales, live in fuel poverty (Association for the Conservation of Energy, 2014).

Fuel poverty will often result in households not being able to achieve sufficient warmth. Substandard housing is already estimated to cost the UK National Health Service £2.5 billion a year (National Housing Federation / ECOTEC, 2010). When energy saving measures are applied in fuel poor communities, often a large proportion of the benefit will be 'taken back' in improved comfort. This take-back, or rebound effect, has been estimated to be up to 50% of the expected energy saving measures (Lomas, 2010).

Referring to the above, some 25% of the UK's 26.4 million housing may experience fuel poverty, which generally contributes to substandard environments, and or the need to improve energy efficiency. This would equate to around 6 million dwellings. Based roughly on the above £2.5 billion health impact from substandard housing, the potential health impact cost per dwelling would equate to an average of £400 per substandard dwelling per year. If say a retrofit dwelling has a health benefit lifetime of twenty years, this equates to a saving of £8,000 per retrofit, by the health industry. So, from this simplistic analysis, reducing fuel poverty can potentially save the health industry considerable amounts of money.

10. COMMUNITY BENEFITS

The above discussion has focussed on the building scale benefits from green buildings, in terms of reduced energy costs, improved well-being and productivity, and increased building asset value. There are also potential benefits to the community in which the building is located. Green housing can increase wealth through reduced operating costs. Green commercial buildings can improve the quality of the built environment, attracting higher value businesses, and creating higher value jobs. There are also jobs associated with green industries, which are often appropriate to the mix of available skills within the local community. For example, the construction sector could create 400,000 new jobs from making buildings more energy efficient to meet the requirements of the Energy Efficiency Directive (European Commission, 2014).

It is difficult to quantify the cost benefit of a green building to the community, but it could be of a level equivalent to the benefit to the building operator, as benefits of increased productivity, asset value may all be reflected in downstream community economic and quality of life benefits, and the increased value feeds through to the community, through higher wages, green jobs, and less pollution.

11. ENVIRONMENTAL DAMAGE

Burning fossil fuel contributes to considerable environmental damage at a global and national level, which results in huge cost penalties. The DARA group have reported (DARA 2012) that climate change is already contributing to the deaths of nearly 400,000 people a year and costing the world more than $1.2 trillion a year, with developing countries bearing the brunt, through deaths from malnutrition, poverty and their associated diseases. Air pollution caused by the use of fossil fuels is also separately contributing to the deaths of at least 4.5m people a year. By 2030, it is estimated that the cost of climate change and air pollution combined will rise to 3.2% of global GDP, with the world's least developed countries forecast to bear the greater cost, of up to 11% of their GDP.

The Stern Review (Stern N, 2006) estimated that the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP each year and the estimates of damage could rise to 20% of GDP or more. In contrast, it suggests that the costs of reducing greenhouse gas emissions to avoid the worst impacts of climate change can be limited to around 1% of global GDP each year.

The most environmentally damaging business sectors are oil and gas producers, followed by industrial metals and mining. These together accounted for almost a trillion dollars' worth of environmental harm in 2008 (PRI, 2010). In 2003, research results on socio-environmental damages due to electricity production and transport (European Communities, 2003) showed that, if the external cost of producing electricity from coal were to be factored into electricity bills, 2-7 eurocents per kWh would have to be added to the then current price of electricity in the majority of EU Member States.

The European Environment Agency reported that air pollution in Europe cost more than 100 billion euros in 2009 alone due to health and environmental damage (European Environment Agency, 2011). Emissions from power plants in Europe made up the largest share of the environmental damage costs, at £56.8bn-£96.4bn. The construction and operation of the built environment is closely linked to these industries. If we assume 40% of electricity is used in buildings the environmental damage equates to around £120 per household per year across Europe. That includes damage associated with global warming, acid rain, resource depletion, habitat destruction by fuel extraction, environmental damage from processing and transportation, and photochemical smog.

Future increases in environmental damage and resource depletion, could potentially lead to governments to apply a "polluter pays" principle. This in turn will affect the built environment, with reduced asset values for non-green buildings, higher insurance premiums on companies, carbon taxes, and the costs associated with retrofits that could be the subject of future changing building regulations.

12. CASE STUDIES

Many of the studies discussed above have been associated with large-scale surveys. However, there are an increasing number of green building projects, both new build and retrofit that are yielding invaluable information on green building design and the resulting benefits. The following case studies, carried out by the author, are used to further evidence some of the above discussion points.

Office design (Figure 1): A green approach to modern office design should adopt an integrative systems approach, to maximise performance, reduce costs and improve reliability. The EMPA zero energy office in Zurich is a good example of this approach, using a combination of ‘smart’ façade design, thermal mass cooling and renewable energy supply (Jones P J and Kopitsis K 2005). It uses a central atrium for night cooling in summer, using a ‘’passive’ approach by exposing the concrete ceiling to absorb daily heat gains from the space. At night the building is naturally ventilated through the atrium, cooling the building down. This is combined with a ground ventilation cooling system, which operates during the daytime, typically cooling outside air by up to 8oC for delivery to the occupied space. The building is highly insulated and does not need a conventional heating or cooling system. The increased cost of the façade is offset by the reduced costs of the environmental systems, so the total costs are comparable to a standard office building. The mechanical ventilation ground cooling system that operates during the day, provides enough fresh air for occupants, and not the larger quantities that would be associated with more traditional air-conditioning systems. Therefore, fan power and space for ducts and systems are reduced. The EMPA building uses passive thermal mass ceiling cooling. This, to some extent, decouples the cooling from the ventilation system. Whereas a standard air cooling (heating) system would be based on the ventilation being provided by the heating and cooling system. This holistic approach to design leads to multiple cost and value attributes, including: lower fan power; less space for plant; less space for air distribution; greater use of space for occupants; good thermal comfort; better air quality; more stable easier to control conditions; good use of daylight. Such an integrative systems approach to new commercial buildings can therefore provide an overall more sustainable design solution at affordable costs.

Figure 1: EMPA zero energy office

Energy positive house (Figure 2): An energy positive house (Welsh School of Architecture, SOLCER Project) has been designed within an affordable budget, equivalent to the standard costs of good quality one-off social housing. It incorporates near PassiveHaus standards, PV and solar thermal renewable energy systems, and has thermal and electrical storage, within the cost budget. The design adopted a systems approach integrating reduced energy demand, renewable energy supply and energy storage. It has electricity grid back-up, for periods when the energy storage system is not sufficient. Its energy positive design means that it can export more energy to the grid than it imports from the grid.

Figure 2: Zero carbon house (SOLCER project)

Individual house retrofits (Figure 3): The SOLCER Project has also carryed out retrofits of existing social housing. The first one completed in September 2014 (Figure 3a) used a whole house 'deep' retrofit systems approach including, solar PV (the whole of the south facing roof is replaced with a PV roof system), MVHR, external wall insulation, battery storage, and increased airtightness. The total package of measures cost around £27,000, with an estimated carbon dioxide emission reduction of 70%. An additional £25,000 was spent by the housing association to bring the house up to current standards. This compares with a previous case study (Figure 3b) for a similar size end-terrace house, which cost around £54,000 to achieve 80% carbon dioxide emission reductions with an additional £70,000 spent on non-energy saving improvements. This previous case study was one of the TSB cases discussed above (M Baeli, 2013), and generally adopted a less integrative more 'bolt-on' approach.

Figure 3a *Figure 3b*

Figure 3: Examples of social housing retrofit. Figure 3a shows a recent retrofit where the whole south facing roof has been replaced by a PV panel. Figure 3b shows a 'bolt on' approach to PV.

For the SOLCER house, prior to retrofit, the house was unoccupied, thus losing the housing association around £450/month in basic rent. Post retrofit, a tenant was easily found, and the house rented at an increased rate of around £540/month (plus 20%), therefore achieving considerable multiple cost benefits for the housing association. There are currently around 20,000 such empty houses in Wales, in many cases where this approach could be implemented, bringing current unoccupied housing back into the market place, so they become an asset rather than a liability to their owners. Bringing empty houses into use also benefits the community and reduces the need for new build.

Large-scale retrofit

Housing retrofit programmes are often carried out on large samples (Jones PJ, et al, 2013). An example is that of the whole housing stock in the Neath Port Talbot local authority in Wales. This targeted lower cost 'elemental' energy saving measures, rather than the deep whole house approach discussed above. It was carried out between 2004 to 2007, and some 49,831 households were assessed, and 28,799 energy efficiency measures carried out to 18,832 properties. Around 28,799 tonnes of carbon dioxide emissions were saved. The project took advantage to provide multiple benefits in addition to energy savings, including: improved comfort; creating 54 new jobs, 127 workers receiving training; 2,305 households removed from fuel poverty; a total £10.3 million invested in the Borough. This project demonstrates the added value that can be applied to large-scale retrofit projects.

The earlier single house and the large-scale retrofit projects have illustrated the range of cost versus energy savings and carbon dioxide emission reductions in relation to shallow elemental measures and deep whole house measures (Figure 4). The recent single house retrofit (Figure 3a) illustrates the speed at which costs are being reduced through a more systems based approach. Both scales illustrate the range of value added benefits in addition to energy savings.

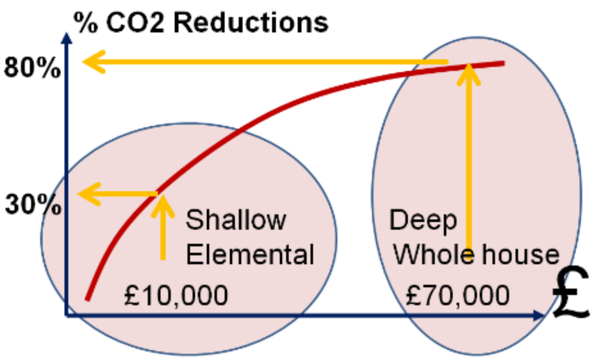

Figure 4: Range of retrofit costs versus carbon dioxide emission reductions (Jones PJ, et al, 2013)

These above case studies indicate that, for new build, it is now possible to achieve near zero carbon performance at an affordable cost. The cost of deep retrofits for housing is also being reduced significantly. Both of these developments have involved a systems approach, carefully selecting the most appropriate combination of reduced energy demand, renewable energy supply and energy storage, to meet the requirements of the specific buildings in question.

13. THE VALUE OF GREEN BUILDINGS

The above sections have introduced a number of issues associated with cost and value of green buildings. Some of the areas covered have associated the estimated costs of the value added aspects of green buildings. In some sections, an estimation has been provided, based on rough values from the literature, with some 'back of envelope' estimates. The intention has been to provide an initial estimation for an overall cost and value estimate. In the estimations, neither increased energy costs nor interest rates have been considered, so they should be considered 'ball park' Figures.

In the past, a cost analysis has mainly related increased cost of a green building against the reduced operating costs, which have been mainly energy savings. What the above discussion has identified is a range of added value factors, some of which are potentially considerably higher than the potential energy savings. It has also identified a scale of value added which benefits not just the building owner, but also considers benefits at community and national (and global) levels. At the national/global level, benefits include, reduced environmental damage (eg. from climate change and air pollution), reduced national health costs (eg. arising from affordable warmth and improved well-being), and security of energy supply and reduced energy imports. At a community level, there is the potential for green jobs, a better quality built environment, and higher value local economic activities. At a building level, which is where the majority of this discussion has been based, the benefits are associated with energy savings, increased value of the building, future proofing, and improved health, well-being and productivity. Table 2 summarises these three areas of green building multiple benefits.

National / Global	Community	Building
• Carbon emissions reduction. • Reduced use of resources. • Security of energy supply. • Improved public health and well-being, and reduced health related costs. • Reduced environmental damage.	• Jobs. • Skills and training. • Local economy. • Less pollution.	• Increased resale value. • Increased rental rates. • Higher occupancy rates. • Lower operating expenses. • Higher net operating income. • Lower capitalization rates. • Increased energy efficiency and lessening greenhouse gas emissions. • Reduced risk of obsolescence. • Less need for refurbishment in the future. • Lower tenant turnover affecting renewals, inducements and fitting out costs amongst others. • Quicker to secure tenants. • Better indoor environment: health, well-being and productivity gains. • Attract grants, subsidies and other inducements to do with environmental stewardship. • Higher demand from institutional investors mandatory for government tenants. • Contribute to company CSR policy.

Table 2: Summary of potential green building cost and value benefits

Office buildings have the potential for considerable added value, in relation to the increased asset value of the building, productivity gains, as well as energy savings, which are relatively small compared to the total benefits. The above discussion has identified a range of sources of information in this area. These have been interpreted into an overall cost value performance. Figure 5 indicates the range of cost benefits for a new 'green' office taken from the above review. Retrofit offices will have a similar range of benefits, although not to the extent of new offices.

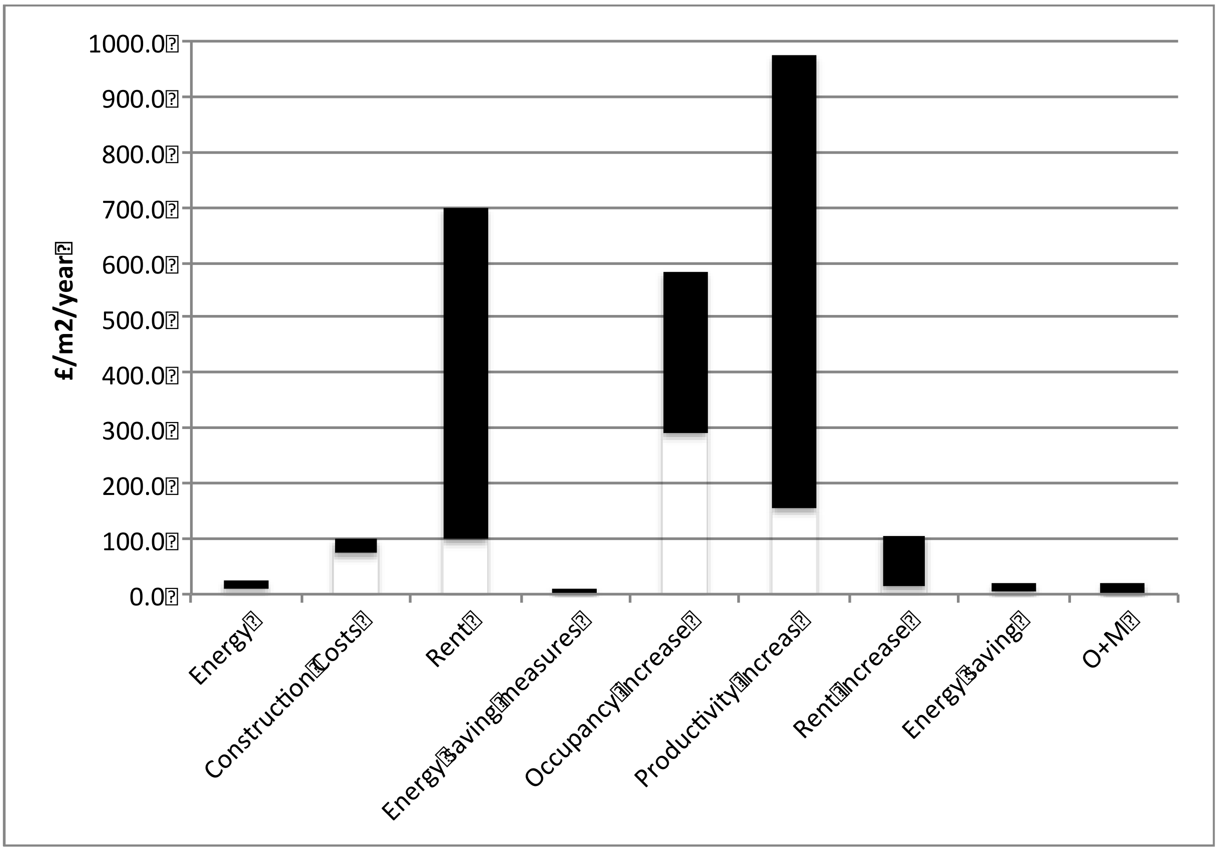

Figure 5: Potential cost savings for a 'green' office

New houses designed to green standards will also incur a range of benefits. The national/global, and to some extent the community benefits, will be as for offices. The building benefits include energy savings, increased value of the building, future proofing, affordable warmth, and improved health and well-being. The range of cost b benefits are summarised in Figure 6.

For new build offices and housing, the increased costs associated with low to zero energy performance are being driven down by new technologies, integrated into the building design through a systems approach. This was demonstrated in the case studies presented above. The cost of retrofit is also being significantly reduced, through the lowering of costs for renewables, improved understanding of the process, and, as for new build, a more systems based approach. This was also demonstrated in the above case studies, for deep housing retrofits. The above discussion has also indicated that retrofit of office costs are highly beneficial with relatively short payback times, in just terms of energy savings.

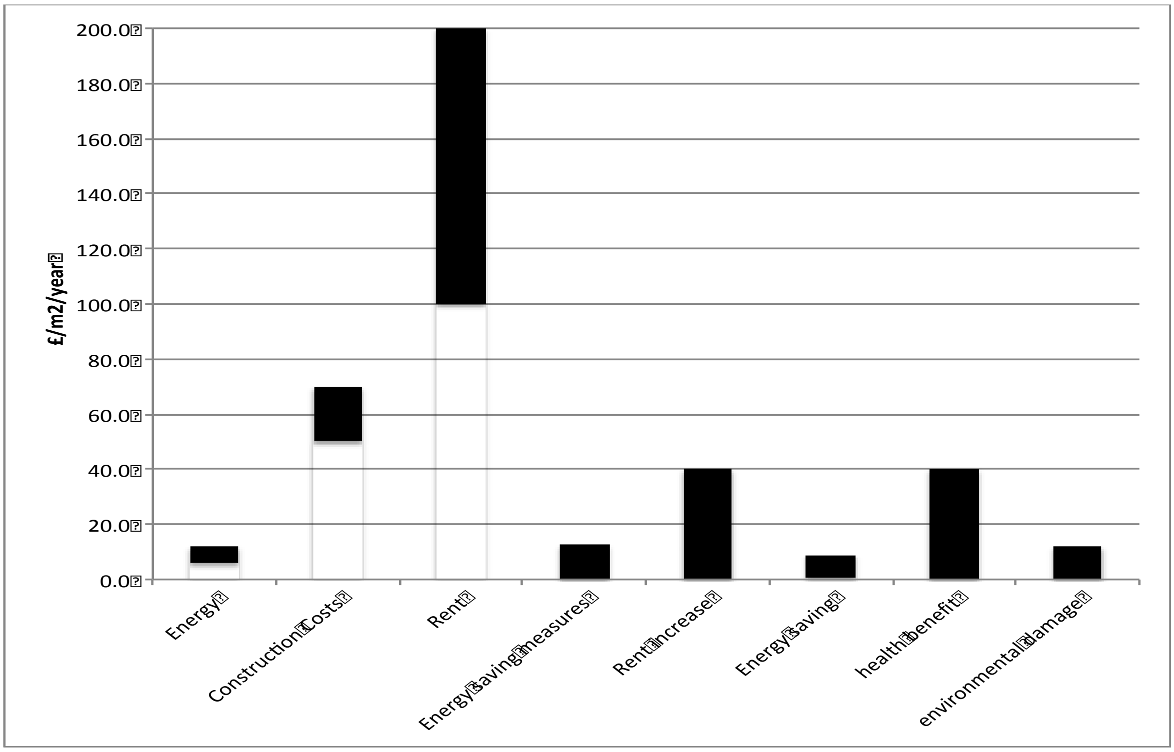

Figure 6: Cost and value benefits for a new 'green' house

14. CONCLUSIONS

This chapter has highlighted the multiple benefits from green building design, in addition to the usual focus on energy savings. There are of course significant energy savings and carbon dioxide emission reductions to be achieved for both new build and retrofit. However, it is the additional 'value added' multiple benefits that are becoming increasingly attractive, and to some extent they are zero or low cost, as the energy savings alone justify the initial green design costs. In summary, green buildings do not necessarily incur significant additional initial cost. For new build, and retrofit, costs are being reduced. The benefits are multiple and both quantitative and qualitative, and are realised at a building, community and national / global scale. Energy savings alone can potentially exceed any design and construction cost premiums, within an acceptable payback period The total benefits can far outweigh any additional cost outlay. Developers who do not provide green buildings incur investment risk, and reduce marketability. Non-green buildings may now be considered short term, and can potentially spiral down the economy. Green buildings can provide better places to live and work, a higher value asset, and generally spiral up the economy at building, community and national levels, and promote tangible benefits to people.

Addressing the low carbon agenda at a building development level may be termed 'bottom-up', compared to say 'top-down' approaches, such as large-scale renewables, carbon trading, smart meters, and green-deals. A bottom-up approach, which is based within an overall systems approach, can be termed 'smart-up', with reference to the added value of a green building as it impacts at higher levels of community and national/global scale, providing the potential for cost and other benefits at these higher levels. It also localises the low carbon agenda, as it promotes economic activity at a regional scale, with potential social benefits, through jobs, local investment and ownership. Top-down approaches may also be termed 'smart' but they are often associated with high risks, and any added benefits are generally more 'big industry' commercial and national based. Smart-up has the potential to reduce the pressure on top down scenario's, making them easier to implement, as demand is reduced, being displaced by building based distributed generation. These factors all contribute to the overall value-added outcomes.

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