UN HABITAT
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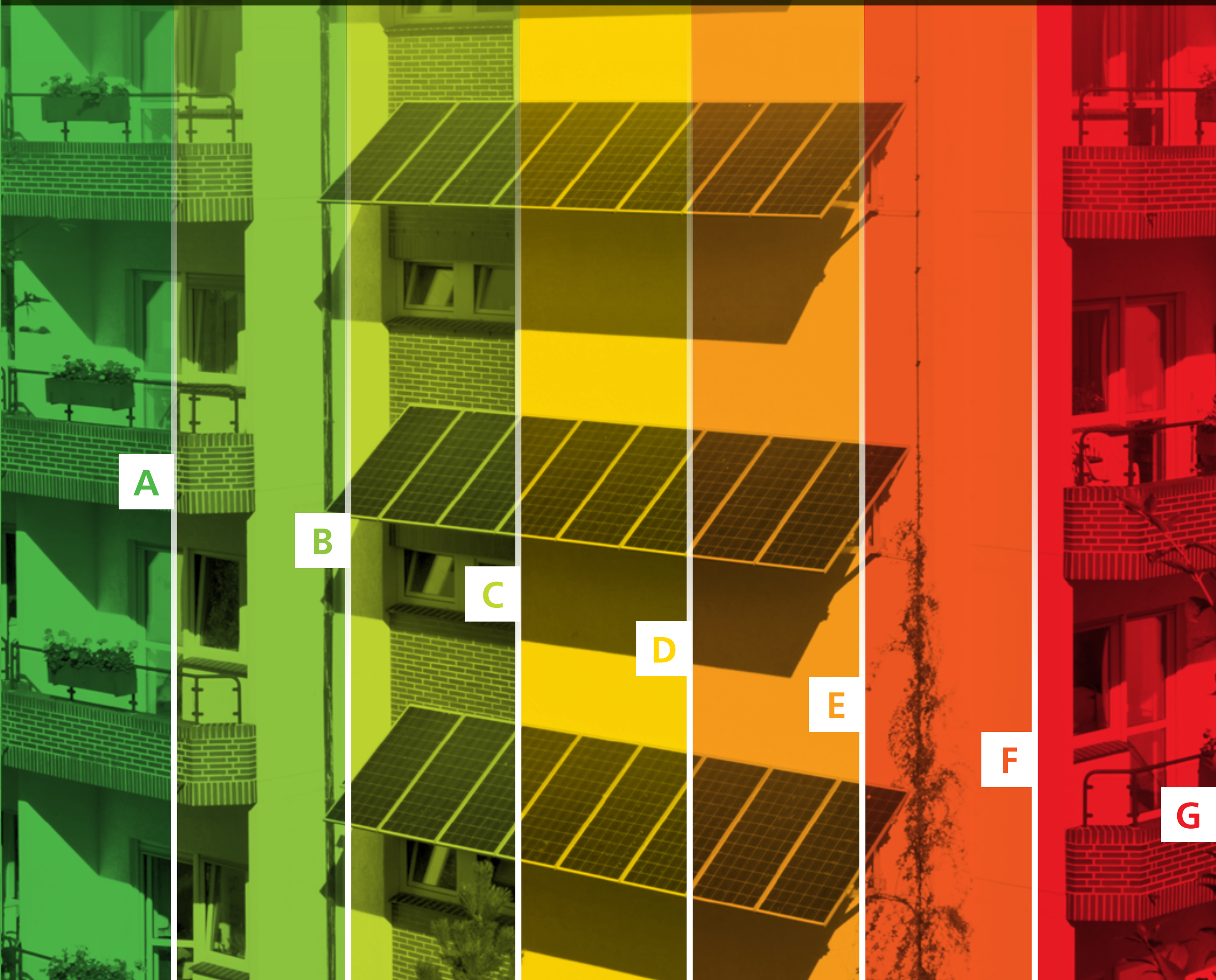
UNEP
Sustainable Buildings and Climate Initiative
Promoting Policies and Practices for Sustainability

GREEN BUILDING

INTERVENTIONS FOR SOCIAL HOUSING



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List of Abbreviations

ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
BEE	Bureau of Energy Efficiency (India)
BMA	Bangkok Metropolitan Administration (Thailand)
BPE	Building Performance Evaluation
BREEAM	Building Research Establishment's Environmental Assessment Method
CBCS	Brazilian Sustainable Construction Council
CDHU	State of São Paulo's Housing and Urban Development Agency (Brazil)
CDM	Clean Development Mechanism
CEF	Caixa Econômica Federal (Brazil's federal savings bank)
CFE	Comisión Federal de Electricidad (Mexico)
CFL	compact fluorescent lamp
CHP	combined heat and power
CO_2	carbon dioxide
CODI	Community Organization Development Institute
CONAVI	Comisión Nacional de Vivienda (Mexico) - Low Income Housing subsidies
CSH	Code for Sustainable Homes (CSH)
DME	Department of Minerals and Energy (South Africa)
DPW	Department of Public Works
DSM	demand side management
EAHP	exhaust air heat pump
EC	European Comission
ECBC	Energy Conservation Building Codes (India)
EE	energy efficiency
EEDSM	energy efficiency demand side management
EEFP	Energy Efficiency Financing Platform (India)
EPC	Energy Performance Certificate
ESCO	energy services companies
EU	European Union
FEEED	Framework for Energy Efficient Economic Development (India)
FiT	Feed-in Tariff
GBCSA	Green Building Council South Africa
GERES	Groupe Energies Renouvelables, Environnement et Solidarites
GHB	Government Housing Bank (Thailand)
GHG	greenhouse gas
GNSH	Global Network for Sustainable Housing
GRIHA	Green Rating for Integrated Habitat Assessment
GSHP	Ground Source Heat Pump
HFH	Habitat for Humanity
HLC	heat loss coefficient
HLP	heat loss parameter
IEA	International Energy Agency
INFONAVIT	Instituto del Fondo Nacional de la Vivienda para los Trabajadores (Mexico)

IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation
kWh	kilo watt hour
LED	light emitting diode
LEED	Leadership in Energy and Environmental Design
LTMS	long term mitigation scenarios
MEPS	Minimum Energy Performance Standards
MME	MINISTÉRIO DE MINAS E ENERGIA (Brazil)
$mtCO_2$	million tonnes of Carbon dioxide
MVHR	Mechanical ventilation with heat recovery
NGO	non-government organisation
NHA	National Housing Association
NI	North Ireland
OECD	Organisation for Economic Co-operation and Development
PHA	Piedmont Housing Alliance (USA)
PROCEL	National Electrical Energy Conservation Program (Brazil)
PV	photovoltaics
REBECEE	Renewable Energy and Building Exhibitions in Cities of the Enlarged Europe
SANS	South African National Standards
SBAM	Sustainable Building Assessment Method
SBCI	Sustainable Building Challenge Initiative
SEPF	Slovenian Environmental Public Fund
SHE	Sustainable Housing Europe
SIP	structural insulted panels
SSB	stabilised soil blocks
SUDS	sustainable urban drainage system
SUSHI	Sustainable Social Housing Initiative
TERI	The Energy and Resources Institute (India)
TSB	Technology Strategy Board (UK)
ULC	Unification of Tenement-Housing Struggles (Brazil)
UNEP	United Nations Environment Programme
UVA	University of Virginia (USA)
WRI	World Resources Institute

Executive Summary

Background

The provision of 'affordable' homes is an issue of profound international importance. It is estimated that 1.6 billion people live in substandard housing and that 100 million people are homeless. The problem is particularly acute in relation to the growing urban sector where every week more than a million people are born in, or move to cities in the global South. Approximately 1 billion people (32% of the global urban population), live in urban slums. If no meaningful action is taken, the United Nations reports that the number of slum dwellers worldwide will increase over the next 30 years to nearly 2 billion.

Responses to this problem have to be holistic, multi-level and interdisciplinary, and must acknowledge local cultural, economic, legislative and environmental factors. Sustainable housing should be seen as a comprehensive process accounting for environmental, social, cultural, economic and institutional considerations (UN-Habitat, 2012a). There is an urgent need to find housing solutions that do not impact adversely on housing affordability and enhance urban livelihoods. Moreover, there is an imperative to find sustainable housing solutions that address the growing carbon footprint of the built environment, and which do not raise more households to levels of carbon emissions that are unsustainable in terms of operational and embodied carbon burdens (as is the current situation with the majority of housing performance in wealthier countries). Such poor performance if replicated in the global provision of affordable housing would exacerbate environmental change. Instead, solutions must be found to address the crisis of affordable housing which also acknowledge the parallel crisis of climate change mitigation. Sustainable urbanization therefore needs affordable, adequate and green housing options in order to respond to the global rapid population growth especially in the low-income housing areas of countries.

Research challenge

Within this context, the purpose of this research is to develop a practically-oriented publication linking the social housing sector of countries with green building interventions which also include instruments for promoting greening of the social housing sector at the legislative/policy, institutional, financial and technical levels. The study is implemented in the framework of UN-Habitat and UNEP collaboration on Sustainable Buildings, and as a part of the activities of the Global Network for Sustainable Housing (GNSH). The GNSH has been created to contribute to the development of sustainable and affordable housing solutions in developing and transitional countries, with a specific focus on improving the social, cultural, economic and environmental sustainability of slum upgrading, reconstruction, large scale affordable housing and social housing programmes.

What this report is about

This report defines the rationale for green building intervention on social housing, details international examples of legislative and regulatory frameworks for enabling green social housing and identifies global and regional forms and approaches to green social housing. A range of technical measures for new social housing and environmental retrofitting of social housing are explained, along with the assessment of case studies, best practice and otherwise ineffective cases. As a key lesson, the importance of engaging residents of social housing through awareness raising and behaviour change is emphasised.

Learning from case studies

It is essential to involve tenants or residents in all discussions at every stage, in order to ensure that they have maximum information on how to best use and live in the dwellings and thus maximise their energy savings and future prospects. In the design and planning stage, always emphasise life cycle costs and not just the initial cost of construction. For participation with residents to be effective, it is vital to involve them at the earliest possible stage (design brief) and to use design teams who have the willingness and necessary skills to work well with residents. Serious consideration for upgrades must be made when bringing occupants out of slums or conditions where they were not previously responsible for fuel, water or sewage bills. In the construction phase, demonstration or mock-ups can be helpful in convincing residents to accept new ideas and in assisting builders in understanding new construction methods or working with new materials. Following occupation, an occupancy review is essential in order to assess the operation of the building and to understand how the building performs compared to expectations; important lessons are always learned from evaluating the performance of the building and listening to occupant's experience.

Monitoring and evaluation of sustainable housing practices is an important tool to demonstrate to various actors, including the political institutions and the national/ international financial institutions, the benefits of sustainable social housing. Monitoring and evaluation should feed into policies and help secure funding. It is important to monitor and evaluate all aspects of sustainable housing including social, economic and cultural. Furthermore, the evaluation methodology can ensure progressive development of green building ideas, design decisions, material use, systems installation and commissioning through the essential step of documentation and forward-feeding of lessons learned. To do this effectively it is essential that all teams involved document, learn from and feed-forward results for future design and construction decisions. A national or local green building group would be invaluable in spreading and enabling the learning from this process.

The report is structured into six main sections:

1. The first section provides a background, aims and methodology for the report
2. The second section defines the rationale for green building intervention on social housing
3. The third section presents a review of relevant policy instruments and the application of policy instruments in a selection of case study countries.
4. The fourth section reviews green building materials, methods, systems and practices.
5. The fifth section presents a selected set of best practice and ineffective case studies are assessed using desk research to provide key messages and recommendations for greening the existing and new social housing sector of emerging economies and developing countries.
6. The sixth section concludes the report.

In addition, an appendix is provided as a checklist in the form of key questions that policymakers can use to review their programmes and policies with regard to the provision of affordable, accessible and sustainable housing.

CHAPTER

01

Introduction

Globally 70 per cent of the nine billion people projected to inhabit the world in 2050 will be living in urban areas. As an example, in India it is predicted that by 2020 about 40 per cent of the population will be living in cities; it was around 28 per cent in 2008 (McNeil et al., 2008). Currently many countries are facing significant housing shortages in urban centres due to rapidly increasing population and urbanisation. In Malawi, for example, it is estimated that there will be a need for 21,000 new households per annum to accommodate population growth (UN-Habitat, 2011a). Many new urban dwellers are projected to be low-income groups not able to participate in the formal housing market, strained by high demand and limited resources only increasing housing prices. Instead, these new urban dwellers will require access to affordable or social housing, or alternatively will end up in slum dwellings (UN-Habitat, 2011). Between 2000 and 2010, fifty five million new slum dwellers were added to the global population (UN-Habitat, 2011a). One of every three people living in cities in the developing world lives in a slum (UN-Habitat, 2013a).

Background and context

According to the Intergovernmental Panel on Climate Change (IPCC) the building sector has the highest potential to reduce energy use (and resultant carbon dioxide emissions) at the lowest cost. The sustainable building agenda is well recognised and rapidly growing in developed countries; however, in most developing countries with the largest and fastest growing building markets, resource efficiency and sustainability objectives are largely neglected in both construction and occupancy periods (UNEP, 2013). Consequently, the world's most populous regions run the risk of locking their economies into inefficient and environmentally detrimental building stock for decades unless efforts are made to introduce and mainstream sustainable building practices. This is especially problematic where in these developing countries there is not only an expansion in construction but there is a large and growing need for affordable housing.

Responses to this twofold problem have to be holistic, multi-level and interdisciplinary, and must acknowledge local cultural, economic, legislative and environmental factors. Sustainable housing should be seen as a comprehensive process accounting for environmental, social, cultural, economic and institutional considerations (UN-Habitat, 2012a). As explained in Going Green: A handbook of sustainable housing practices in developing countries, sustainability is more than environmental considerations, wherein social sustainability focuses on empowerment and participation in the housing process and beyond, economic sustainability focusses on job creation and income generation through the process of creating affordable housing, cultural sustainability focusses on respecting the cultural heritage of the people and the built environment, and finally, institutional sustainability focusses on government support and responsibility.

Much work is being done to promote sustainable social housing in developing countries. The Sustainable Social Housing Initiative (SUSHI), initiated by the United Nations Environment Programme (UNEP) in 2009, involved pilot case study projects in Bangkok, Thailand and Sao Paulo, Brazil. The pilot projects aimed to serve as demonstration projects to raise the awareness and initiate cooperation between market actors in these locations. From 2009 to 2011, project teams in each location developed a local approach and selected targeted solutions to improve sustainability in social housing considering local priorities, challenges and previous experiences (UNEP, 2013). The Global Network for Sustainable Housing, established through the United Nations Human Settlements Programme (UN-Habitat), is a partnership that includes several international organizations that are promoting adequate housing solutions in the context of slum upgrading, reconstruction, large-scale affordable and social housing, and sustainable urban development. The GNSH works to link practitioners, academics and organizations that are leading the policy development, research and design for environmentally, economically, socially and culturally sustainable housing. Through the partnership, GNSH members share experience and expertise, and develop strategies that promote affordable and sustainable housing practices in developing and transitional countries and cities (GNSH, n.d.). Finally, the Building and Social Housing Foundation (BSHF), an independent research organisation that promotes sustainable development and innovation in housing through collaborative research and knowledge transfer, among other important activities, organises the annual World Habitat Award competition to identify innovative housing solutions worldwide. The World Habitat Award presents £10,000 annually to two exemplar groups that provide practical and innovative solutions to current housing needs and problems. Environmental, social and economic sustainability are fundamental details of the winning case studies (WHA, 2014).

Aims, research methodology and outputs of the study

The aim of this report is to develop a practically-oriented publication linking the social housing sector of countries with green building interventions which also include instruments for promoting greening of the social housing sector at legislative/policy, institutional, financial and technical levels.

The publication aims to assess the current situation and practices but also to give recommendations and inspiration for new countries to invest in green social housing programmes.

The methodology of the study is as follows:

- A critical review and systematic analysis of literature comprising of refereed journal articles, research reports, policies, standards, principles and grey literature
- Review of policy instruments on greening the social housing sector.
- An analytical framework is used to select, assess and summarise best practice and less effective case studies of green social housing projects: the case studies were selected from transitional, developing and developed countries.

Summary of chapters: Readers' guide

The report is structured into six sections with an appendix:

- The first section provides a background, aims and methodology for the report.
- The second section defines the rationale for green building intervention on social housing.
- The third section presents a review of relevant policy instruments and the application of policy instruments in a selection of case study countries.
- The fourth section reviews green building materials, methods, systems and practices.
- The fifth section presents a selected batch of best practice and ineffective case studies are assessed using desk research to provide key messages and recommendations for greening the existing and new social housing sector of emerging economies and developing countries.
- The sixth section concludes the report.
- Appendix A provides a checklist in the form of brief questions, is provided, that policymakers can use to review their programmes and policies with regard to the provision of affordable, accessible and sustainable housing.

CHAPTER

02

Green building interventions in the social housing sector

Rationale for green building intervention in the social housing sector: A win-win scenario?

In December 2012, the United Kingdom-based Commonwealth Development Corporation (CDC), a development-finance institution, put up $20m for social housing investments in Eastern and Southern Africa. The investment is projected to create 7,500 homes and more than 20,000 jobs. In Gabon the government is targeting the 'most disenfranchised' by constructing 35,000 homes by 2017, there is concern however of the lack of consultation resulting in possible neglect of social and cultural considerations. In Ghana housing is high on the development agenda (The Africa Report, 2013). In Venezuela the annual target for affordable housing is 300,000 per annum (Perry, 2013) and in Brazil 500,000 per annum (UN-Habitat, 2013b). In China there is a vast national effort to build subsidized housing for the urban poor and at the same time boost the economy through the steel, cement, copper, and aluminium industries. Five million affordable apartments were scheduled to be built in 2012, with a goal of reaching 36 million units by the end of 2015 (Roberts, 2012).

Housing development creates multiple environmental challenges. There is an urgent need to find housing solutions that do not impact adversely on housing affordability and enhance urban livelihoods. Moreover, there is an imperative to find sustainable housing solutions that address the growing carbon footprint of the built environment, and which do not raise more households to levels of carbon emissions that are unsustainable in terms of operational and embodied carbon burdens (as is the current situation with the majority of housing performance in wealthier countries). Such poor performance if replicated in the global provision of affordable housing would exacerbate environmental change.

In order to provide equitable housing for the growing population in need, there will undoubtedly be an increase in energy consumption and GHG emissions as currently the housing sector is responsible for a large proportion of all energy consumption and GHG emissions in the world (UN-Habitat, 2012a). Inevitably the construction of housing requires material production, material transport, unused material disposal (or recycling), land use. Housing occupation results in the displacement of rainwater, potable water consumption, energy consumption, the production of waste and eventual material replacement and possible end of life disposal (or re-use and recycling) (Majumdar & Kumar, n.d.). Table 2.1 lists these challenges and best and worst cases for meeting these challenges.

The complex issues of poor economic infrastructure and extreme poverty in developing countries have resulted in increased environmental problems (CIB & UNEP-IETC, 2002). Green social housing has the capacity to directly or indirectly tackle the existing problems in cities such as solid waste management, storm water management, water supply, sanitation, and mosquito control (UN-Habitat and UNEP, 2009). Green housing is also concerned with the indoor air quality provided to occupants, since for example; 1.3 million people die prematurely each year due to exposure to indoor air pollution from biomass combustion (UNEP SBCI, 2009a).

Benefits of green housing

Globally, with proven and commercially-available technologies, the energy consumption in both new and existing buildings can be reduced by 30-50% without significantly increasing the investment costs of new construction or renovation projects (UNEP SBCI, n.d.). Solutions include improved insulation, well-designed fabric, smart design (e.g. appropriate orientation for solar access), low energy appliances and cooling/heating systems, water-saving devices, water recycling and harvesting, and incentives to building users to save water and energy. According to the Intergovernmental Panel on Climate Change (IPCC), the housing sector has the most potential for improvement without extra cost in the near future (UN-Habitat, 2012a). Unmet or suppressed demand and the rebound effect (Galvin, 2014) however, can offset these savings.

TABLE 2.1 ENVIRONMENTAL CHALLENGES IN HOUSING CONSTRUCTION AND OCCUPATION

	At best	At worst
Material production	Local material harvested and produced onsite / or transported from a nearby town or city	High embodied energy materials, e.g. Portland cement, steel
Material transport		Materials transported from various other countries
Unused, leftover construction material	Reused elsewhere / recycled	Landfill
Land use	Brownfield – land reuse or existing building reuse	Greenfield development – serious natural habitat displacement, e.g. wetland, loss of forest, resulting in flooding, pollution and urban heat island
Displacement of rainwater	Rainwater collection and use on site	Poor management of onsite drainage, ingress leading to building damage and mould growth / rainwater displacement leading to flooding and water pollution
Potable water consumption	Reduce potable water consumption using low flow faucets, rainwater use, greywater use, composting toilets	Typical construction practices, e.g. heavy potable water use for toilets
Energy consumption	Energy generation on site, e.g. photovoltaic panels, solar hot water panels; use of thermal mass to regulate temperature swings; passive solar spaces	Typical energy consuming practices, no awareness of solar benefits, no shading when needed, poor insulation standards.
Waste	Reuse, recycling, composting toilets, waste incineration for local heat and energy	Material and biological waste on streets and in public passage and water ways, landfill
Building end of life	Reuse and recycle	Landfill

Awareness and knowledge of the various issues involved, local context and options available are required to make good ‘green’ choices. Possible environmental, financial and social benefits of higher resource efficiency savings in homes include (Environment Agency, 2005; Majumdar & Kumar, n.d.):

- Minimise depletion of natural resources during construction (less material waste) and operation (less/no fossil fuel use) through use of efficient building materials, construction practices and renewable sources of energy
- Reduced operational costs of homes (lower utility bills) - Knock-on effect of a reduction of people and households in fuel and water poverty.

- Use of efficient waste and water management practices
- Provision of comfortable and hygienic conditions; improved health of occupants.
- Reduced transport costs (assuming the sustainable urban context).
- Reduced macro-infrastructure requirements (e.g. electricity demand).
- Far reaching environmental benefits from reduced pollution and resource use
- Local natural building material benefits: low embodied energy, reduced transport, easier to maintain, and potential for reuse and recyclability
- Local materials (easily repaired or replaced), and reduced energy and water consumption inevitably contribute to lower life-cycle costs of houses

Creation of green jobs

In many cases (see Section 5), some green social housing developments or projects involve the future occupants in the planning, design and construction of their housing. In many cases this provides people with valuable planning, building and political skills to apply elsewhere locally. At the same time, the green building market has the capacity to create a demand for a variety of new jobs and skill sets. These skill sets are extremely widespread whereas, green building choices can be made at all stages of inception, design and development: briefing (scale, location, strategy, environmental impact studies); planning/ design (site/ orientation, systems); specification (materials, systems, utility services); construction (methods, waste management, preservation of habitat); handover and review (occupant needs and understanding); maintenance; renovation (adaptation to new needs); and demolition (including re-use of materials). Furthermore, evaluation of building performance allows learning to be fed back and inform future projects/decisions.

Despite the challenges (outlined in Section 2.4), integrating green building solutions in subsidized housing units can bring important environmental, social and economic paybacks to low-income inhabitants and to the society as a whole. This would support sustainable urban management and socio-economic development while enhancing resource use at local level. Implementing sustainable concepts may result in considerable savings in natural resources while reducing the housing shortage. Consequently, sustainability in social houses can be a win-win for all stakeholders since money is saved in the life cycle of buildings and this profit could be shared amongst all stakeholders.

Potential for contribution of sustainable social housing to climate change mitigation

Given the substantial growth in new construction in economies in transition, and the inefficiencies of existing building stock worldwide, if nothing is done, GHG emissions from buildings will more than double in the next 20 years. Therefore, if global targets for GHG emissions reduction are to be met, it is essential that mitigation of GHG emissions from buildings must be on every national climate change strategy. Tackling the emissions problem from the building sector, for example through green social housing, can create jobs, save money and most importantly, shape a built environment that has a net positive environmental influence. Investing in achieving such results in the social housing sector has the potential to boost the local economy and improve living conditions, particularly for low-income communities (UNEP SBCI, 2009a).

The technologies and know-how for designing and constructing green buildings are well developed and available in most countries as commercialised and publicly available information and services (UNEP, 2011). Green building provides significant energy-savings as high as 60 per cent compared to typical houses in various climatic conditions at normal costs: in cold (Wall, 2006, cited in Flores Larsen et al., 2008), tropical (Garde et al., 2004, cited in Flores Larsen et al., 2008), Mediterranean (Cardinal and Ruggiero, 2000, cited in Flores Larsen et al., 2008), and hot summer/cold winter climates (Feng, 2004, cited in Flores Larsen et al., 2008). Savings can be achieved through the following (Halliday, 2008):

- Simplicity in design
- Energy conservation
- Passive design
- Orientation
- Avoiding oversizing
- Native landscaping
- Lighting efficiency
- Waste management
- Attention to power
- Design for flexibility
- Good air quality
- Water conservation
- Reduction of emissions
- Material efficiency
- Design or operation and maintenance

In addition, reduction in construction related imports as a result of sustainable practices can significantly reduce transportation emissions.

New, well designed buildings will improve indoor thermal comfort levels and provide an opportunity to encourage behavioural and thought patterns which are energy efficient and resource friendly. Since the core concept of "thermal comfort" is more of a state of mind (reflecting different cultural, class and geographical conditions) than a technical certainty (ANSI/ASHRAE Standard 55, 2010) the adoption of western benchmarks for comfort (achieved by active cooling technology) should be vigorously discouraged. Improving awareness about good behavioural practices and natural ability to adapt to a range of temperatures can impact the way future generations use energy.

Emerging approaches of social housing and linkages to green building

Vernacular approaches to building design: Vernacular approaches to social housing are being used in Iran (Afshar, et al., 2012), Papua New Guinea, Senegal and Mali (UN-Habitat, 2012a) to name a few. Vernacular design has been established to advance the sustainable aspect in housing in the following ways (Afshar, et al., 2012):

- **Social/ cultural Sustainability:** culturally sensitive, proven design of safe and secure homes;
- **Environmental Sustainability:** resource-efficiency in handling waste, water and energy; and
- **Economic Sustainability:** cost-efficiency over time.

As an example, in Iran the vernacular is defined by five fundamental principles, compatibility with the needs of the people, inward-looking, avoidance of unnecessary elements, self-efficiency, and structural rigidity (Afshar, et al., 2012). Real examples of the impact of vernacular materials and methods in housing include, thick walls which act as thermal mass to store and release heat when beneficial to the occupants, deep roof overhangs to protect facades from driving rain and sun, appropriate design for local extremes, reduced transport and processing emissions of materials, minimised material and building costs, and ease of training local workers in the use of local materials and traditional methods (Afshar, et al., 2012; UN-Habitat, 2012a).

Energy efficient buildings: energy efficiency is attained by reducing the amount of energy that is required in a typical building. Efficiency is commonly achieved through passive means, e.g., proper orientation of the building onsite, shading windows from incident solar radiation, use of thermal mass, improved insulation, and other means such as using energy efficient lighting (LEDs) and cooking appliances (UN-Habitat, 2012a). Case studies in Section 5 describe some of these energy efficiency measures applied in social housing.

Green buildings: Green building can include energy efficiency along with other features such as healthy materials, water efficiency, sustainable waste management, resource efficiency, and land use. Often materials and methods used to incorporate green aspects have synergistic properties providing energy efficiency and providing other benefits such as resource efficiency. As an example a low flow shower head while reducing water consumption will also reduce the energy required to heat the water.

High performance / 'Near zero' energy buildings: High performance or 'near zero' energy buildings are buildings that use less energy than a typical building. High performance is achieved through passive or technological methods. Ideally, high performance buildings passively achieve energy efficiency before using technology to offset the remaining energy use; however, technically this is not required.

Challenges and opportunities in integrating green interventions in social housing

Challenges to integrating green interventions in social housing

Historically, it is rare for social housing programmes to consider the impact of construction on the natural environment, or the life quality of the users. This is the case in both developed and developing countries. There are however significant opportunities to use social housing programs to improve the energy consumption, local economic development, and health and well-being of occupants (UNEP, 2013). The reasons for this negligence can be attributed to the following challenges:

- **Lack of confidence about the real benefits** of green buildings to individual homeowners.
- **Time and budget constraints:** The need for housing is often urgent and funding is usually minimal. These constraints easily detract from sustainability or environmental health, and result in replication of standard details without consideration for traditional building knowledge, local climate, orientation or actual user needs. Even when green interventions are designed in to the brief, rushing development can result in miscommunication, skipping over commissioning of systems and neglecting to check if work was performed properly. These situations can be detrimental and can often lock-in inefficiencies for the life of buildings.
- **Inadequate and expensive resources:** Access to skilled workers and construction materials and equipment is usually limited and/or too expensive as a result of the growing demand. Social housing programs are always competing with commercial projects to absorb resources while they are often relatively less well funded.
- **Incorrect perception about the amount of energy consumption in social housing:** It is incorrect to assume (as is commonly done) that there is no need to invest in energy demand reduction in social housing due to the perceived low levels of energy consumption in these buildings. However, it still has to be admitted that energy and water consumption and associated cost per household is less compared to typical house, and therefore, energy and water efficiency, and conservation are often a low priority for individual homeowners of social housing projects.
- **Wrong perception of real costs of sustainable alternatives:** Stakeholders and investors are often discouraged by the slight increase in upfront cost of green building solutions while not evaluating the true life-cycle cost benefits. It is proven that many sustainable features –such as site selection, attention to layout, form and window orientation - have little or no additional capital cost while bringing cost benefits during occupancy. Spending money on fabric and design time instead of mechanical services equipment is a reasonable budget balancing method. Furthermore, although some sustainable solutions cost more at the beginning, they can provide both capital and running costs since heating and cooling systems would be smaller (Halliday, 2008)
- **Land-use constraints:** Social housing is difficult to integrate in existing urban contexts due to land costs and availability of land. Disconnection from urban social and economic life is highly unsustainable and contributes to high commuting distances for workers, little access to infrastructure, services and social and economic opportunities.
- **Lack of related skills, research, and knowledge among stakeholders:** Lack of awareness is another barrier. Stakeholders such as developers and financiers could benefit from performance data for decision making.
- **Fragmentation in the process of design, construction, use and maintenance over the life-cycle of a building:** As the building is commissioned by an agency, designed by a different company, built by a third party

and inhabited by different users, there is little communication between actors. This impedes a long-term vision and results in a failure to consider distribution of life-cycle costs across the life of a building. Similarly, split incentives is a barrier hampering the uptake of green buildings. Project promoters may not have any incentive to incorporate energy efficiency and water efficiency in their projects, as they do not get paid back for their investments as the benefits would go only to the homeowners or tenants. Home owners and tenants have the same disincentive (Sreshthaputra, 2010).

Opportunities and benefits of integrating green interventions in social housing

Despite the challenges, integrating green building solutions in subsidized housing units can bring important environmental, social and economic paybacks to low-income inhabitants and to the society as a whole. Specifically, green growth can re-evaluate and build upon traditional construction practices which are often socially and environmentally sustainable and suited to local climate and context. In addition, green construction can offer considerable employment opportunities for traditional activities like bricklaying and unskilled labour; there is also the opportunity for training the labour force in more specialised skills such as installation of PV equipment (e.g., solar panels), solar hot water systems, as well as upstream and downstream occupations in supply, management and maintenance of specialised equipment (Keivani et al., 2010).

Governments in developing countries can take major steps toward developing a supportive institutional and financial framework for facilitating green interventions in social housing. Such measures include (Keivani, et al., 2010):

- Developing an appropriate legislative framework that clearly sets out the benefits of green interventions, emphasising the refinement of environmental considerations rather than requiring major technological shifts.
- Devising an appropriate financial framework with tax and, if possible, grant schemes that encourage green building interventions in social housing.
- Clearly setting out the role of different stakeholders and facilitating their participation in the development process.
- Information awareness and information-sharing activities targeted at all stakeholders through formal national sustainable building information packages, regulations, media campaigns and project consultation meetings.

It is important to note, however, that not all potential design and construction impacts are beneficial (whether green or not), for example it may involve displacement/relocation of people or an increased population placing increased demands on infrastructure facilities like schools and hospitals. Theoretically however, the development is not sustainable when negative impacts occur whether environmental, social or economic. Sustainability should be applied in a holistic manner to provide:

- Quality of housing units (longer lifetime, less maintenance, less defects);
- Quality of life (healthier environment, well-being);
- Market opportunities (local products promoted, more sustainable materials);
- Reduced environmental impact and costs over the life cycle; and
- Urban planning and Social integration/ interaction.

Summary

As the levels of atmospheric CO_2 continue to rise beyond what was considered a safe level it is becoming critical that the world's emissions must be reduced to avoid devastating consequences (IPCC, 2014). At the same time there is urgency for affordable, habitable housing for the increasing number of people living in less than humane conditions.

The building sector is a significant source of energy and water consumption and waste. This consumption not only occurs during the use of the building but before in areas such as material production and construction. Green housing have been proven to be effective in reducing GHG emissions, water consumption, and material waste. With proven and commercially-available technologies, the energy consumption in both new and existing housing can be reduced by 30-50% without significantly increasing the investment costs of new construction or renovation projects (van der Lugt, 2009). These benefits can be coupled with the potential to create green jobs. Creation of jobs and improved labour skills are the products of conscious consideration of social environments during planning and construction (Pearce, 2003). Ultimately, considering the pressures of growth and development in developing countries, sustainable construction of social housing is a severely urgent agenda; it is imperative to look to green building as it offers the most feasible source for reducing demand on energy supplies, direct and indirect CO_2 emissions, and has the potential to improve economic growth.

CHAPTER

03

Green building policy measures for greening social housing

Policy options for greening new and existing social housing programmes

In their Assessment of Policy Instruments for Reducing GHG emissions from buildings, UNEP has classified green/sustainable building policy into four categories (UNEP SBCI, 2009a; Environment Agency, 2005):

1. Regulatory and control instruments: Building Regulations, planning legislation and controls, etc. Local regulations to complement and build on to national standards.
2. Economic and market-based instruments: Energy savings performance contracting; energy efficiency certificate
3. Fiscal instruments and incentives: Tax subsidies for more efficient products, tax penalties/ product charges on non-sustainable building materials and equipment, local tax subsidies for homes built to higher standards, financial assistance/ capital support for the sustainable installations and preferable rate mortgages for resource efficient homes.

4. Support, information and voluntary actions: The public sector leads with regulations requiring all public buildings to be built to high energy performance standards to accelerate the pace of innovation and mainstreaming higher standards, helping to bring down; building information, e.g. manuals, explaining how to achieve the optimal environmental performance.

These policies are generally assessed for cost effectiveness and effectiveness in actually reducing GHG emissions (Table 3.1 – following page). Many policy instruments were found to be effective in achieving emission reductions and in actual cost savings (benefits of saved energy and the associated avoided expenses are factored into the cost-benefit assessment). Regulatory and control instruments were found to be effective in emissions and cost reduction. These instruments, specifically building regulations and local complementary regulations, can be used to ensure a certain standard of green housing, requiring the benefits of sustainable development to be provided for all citizens regardless of economic position or tenure, notably those in social housing.

Where higher standards are achieved through nationwide regulation and standards, the developer will initially have to pay any increased cost. However, where the developer can use the environmental credentials of the houses to differentiate them from conventional homes, any increased cost may be passed on to the house buyer through a higher selling price. In social housing, there will need to be local incentives to assist developers in developing sustainable housing such as making it easier to obtain planning permission. In addition, financially incentivising greening of social housing along with local incentives will encourage developers. As an example, whereas some cities require or incentivise developers to allocate a proportion of development to social housing, similarly sustainable measures can be regulated and provision of sustainable housing can be incentivised through the 'enabling approach' (UN-Habitat, 2011c) (or further incentivised beyond what is required), thereby creating green social housing through two methods.

Economic and market-based instruments also scored fairly well on both counts, as did tax exemptions and reductions (fiscal instrument). Many of the instruments can achieve high savings at low and even negative costs when adapted to the local situation (UNEP SBCI, 2009a). Fiscal instruments and incentives are effective in encouraging development of green social housing and can be complementary to regulatory and control instruments. The general taxpayer pays the most when financial or economic incentives are used to encourage higher resource efficiency standards. However this redistribution could be justified by the long term national saving from avoided environmental/ clean-up costs and the fact that poorer households tend to benefit most from reduced utility bills. Building codes, standards and regulations should ensure social, cultural, environmental and economic sustainability in housing, should be inclusive of all sectors of the population, and should include the use of sustainable technologies, materials and methods (UN-Habitat, 2012a).

TABLE 3.1 SUMMARY TABLE OF POLICIES TO REDUCE GHG EMISSIONS IN THE BUILDING SECTOR

Policy instruments	Emission Reduction Effectiveness	Cost-effective-ness	Special conditions for success, major strengths and limitations, co-benefits
Regulatory and control instruments			
Appliance standards	High	High	Factors for success: periodical update of standards, independent control, information, communication, education
Building codes	High	Medium	Only effective if enforced and periodically updated
Energy efficiency obligations and quotas	High	High	Continuous improvements necessary: new energy efficiency measures, short term incentives to transform markets
Mandatory audit requirement	High, but variable	Medium	Most effective if combined with other measures such as financial incentives
Labelling and certification programs	Medium/High	High	Mandatory programs more effective than voluntary ones. Effectiveness can be boosted by combination with other instrument and regular updates
Demand-side management programs (DSM)	High	High	Tend to be more cost-effective for the commercial sector than for the residential sector.
Economic and market-based instruments			
Energy savings performance contracting (EPC)/ESCO support	High	Medium	Strength: no need for public spending or market intervention, co-benefit of improved competitiveness.
Cooperative procurement	High	Medium/High	Combination with standards and labelling, choice of products with technical and market potential
Energy efficiency certificate schemes/white certificates	Medium	High/Medium	No long-term experience. Transaction costs can be high. Institutional structures needed. Profound interactions with existing policies. Benefits for employment
Kyoto Protocol flexible mechanisms	Low	Low	So far limited number of Clean Development Mechanism (CDM) & JI projects in buildings

Fiscal instruments and incentives			
Taxation (on CO_2 or fuels)	Low / Medium	Low	Effect depends on price elasticity. Revenues can be earmarked for further energy efficiency support schemes. More effective when combined with other tools
Tax exemptions/ reductions	High	High	If properly structured, stimulate introduction of highly efficient equipment in existing and new building.
Public benefit charges	Medium	High	Success factors: independent administration of funds, regular monitoring & feedback, simple & clear design
Capital subsidies, grants, subsidised loans	High / Medium	Low	Positive for low-income households, risk of free-riders, may induce pioneering investments
Support, information and voluntary action			
Voluntary and negotiated agreements	Medium / High	Medium	Can be effective when regulations are difficult to enforce, combined with financial incentives, and threat of regulation
Public leadership programs, including procurement regulations	Medium / High	High/Medium	Can be effectively used to demonstrate new technologies and practices. Mandatory programs have higher potential than voluntary ones
Education and information programs	Low / Medium	Medium/High	More applicable in residential sector than commercial. Best applied in combination with other measures
Detailed billing and disclosure programs	Medium	Medium	Success conditions: combination with other measures and periodic evaluation

UNEP SBCI, 2007

Several instruments have very different impacts in different countries; high in some cases and low in others. This is likely due to differences in policy tool design and implementation to the local context such as income levels and energy prices as well as due to interactions with other instruments already in place in the country. In developed and developing countries, overall, appliance standards, building codes, labelling certification programmes, utility demand side management (DSM) programs and tax exemptions achieved the highest savings (cost-effectiveness of CO_2 reduction). In developing countries, regulatory and control measures have been found to be the most effective and cost-efficient techniques, as shown by UNEP case studies. They all achieved ratings of high or medium according to both criteria. Measures which can be designed both as voluntary and as mandatory, such as labelling/ green building certification programmes or energy efficient public procurement policies have been revealed as more effective when they are mandatory. However, enforcement problems can seriously undermine the effectiveness of these instruments, especially in developing countries (UNEP SBCI, 2007).

Aside from policy incentives there are inherent potential benefits to the developer from building to enhanced resource efficiency standards (Environment Agency, 2005). These are:

- Potential waste reductions associated with the construction process. The construction sector produces millions of tons of waste each year and a significant portion of the delivered materials are never used.
- Demonstration of sustainability credentials to local authorities, investors and consumers. Added value and performance against competitors (competitive advantage) where the developer is able to establish a position as a market leader in developing sustainable homes.
- Knowledgeable foothold and relevance with regard to forthcoming new regulations and legislation.

Enabling legislative and regulatory frameworks

To scale up green social housing, the institutional framework of housing must have sustainability as a goal. Because governmental policies guide urban growth, land use, and housing regulation, institutional support has a direct and indirect impact on sustainability inside and outside of housing. Governments and laws through policy and institutions should support green social housing to meet social housing demand. Institutional sustainability maintains presence, strengthens abilities and guides evolution of mandates which are essential in ensuring long term environmental, cultural, social and economic sustainability. Particularly in developing countries, where legislative and regulatory frameworks do not exist or are lacking, institutional support for achieving green social housing is crucial (UN-Habitat, 2012a).

In addition to the will to meet sustainability objectives there must be the capacity to enforce regulatory policies; lack of enforcement has been identified as a major weakness in energy policies in developing countries. There also must be the support to train professionals in the technical knowledge and skills and the capacity to collect, analyse and use data pertaining to sustainability indicators, e.g. energy consumption (UNEP SBCI, 2009a). Monitoring and evaluation (research that can include occupant comfort studies, energy and water consumption figures) is an important tool which can be used to demonstrate the environmental, economic and social benefits of sustainable housing and the effectiveness of certain policy instruments (UN-Habitat, 2012a). Comprehensive building level energy data is proven to be essential in shaping and verifying the impact of energy policy. Upon review of the CO_2 emission reduction approaches in USA, UK and India, Gupta and Chandiwala (2012) revealed that the UK had good CO_2 reduction policies in place, but limited bottom up energy data sources to verify the impact of these policies; USA had access to relevant data on energy use and profiles from the EIA and US DOE but lacked substantial policy targets to promote energy efficiency; while India was lacking in both data sources and substantial policy infrastructure, a situation which is complicated by the large rural/ urban divide.

Supporting financial mechanisms

Building codes alone will not ensure the progressive steps needed to provide green social housing. Countries need to go above standards by implementing other drivers such as subsidies, tax incentives and feed-in-tariffs.

Capital Subsidies, Grants, Subsidized Loans and Rebates

Capital subsidies, grants, subsidized loans and rebates are used in many countries to encourage building owners and occupants to invest in energy efficiency measures and equipment. Subsidies are very common in the residential sector in order to overcome the major barrier of high first costs. They have been used to finance better insulation such as roof insulation in the U.K., more efficient equipment such as refrigerators in Germany, and energy audits in France. Some governments have also introduced soft loans schemes whereby loans for installing energy efficiency equipment are offered at a subsidized interest rate.

Some governments prefer to use fiscal measures such as tax incentives to encourage investment in energy savings and efficiency measures in buildings. For the residential sector, tax credits and tax deductions are most popular. Almost 40 percent of OECD countries offer tax credits for energy efficiency measures. The World Energy Council (WEC) found that fiscal incentives are considered better than subsidies in that they cost less, but that they usually have a poor performance in an economy in recession or in transition (UNEP SBCI, 2009a).

Fiscal Incentives for the Purchase of Energy Efficient Equipment

Though less common than appliance standards, some governments have tried to encourage the use of energy efficient appliances through fiscal incentives. The most popular are reductions on import tax or VAT on efficient equipment. The compact fluorescent lamp is the most common equipment for this type of measure outside of the OECD, such as in Ghana, Morocco and Israel (UNEP SBCI, 2009a).

Public Benefit Charges

Public benefit charges, similar to energy taxes where revenue is invested in energy efficiency, raise funds from the operation of the energy market to be directed into demand side management (DSM) and energy efficiency activities. As an example, in Brazil, all distribution utilities are required to spend at least one percent of their revenues on energy efficiency improvements, while at least one-quarter of this amount has to be spent on end-use efficiency projects. Effectiveness in terms of the total amount of GHG saved is moderate (UNEP SBCI, 2009a).

Green Mortgages

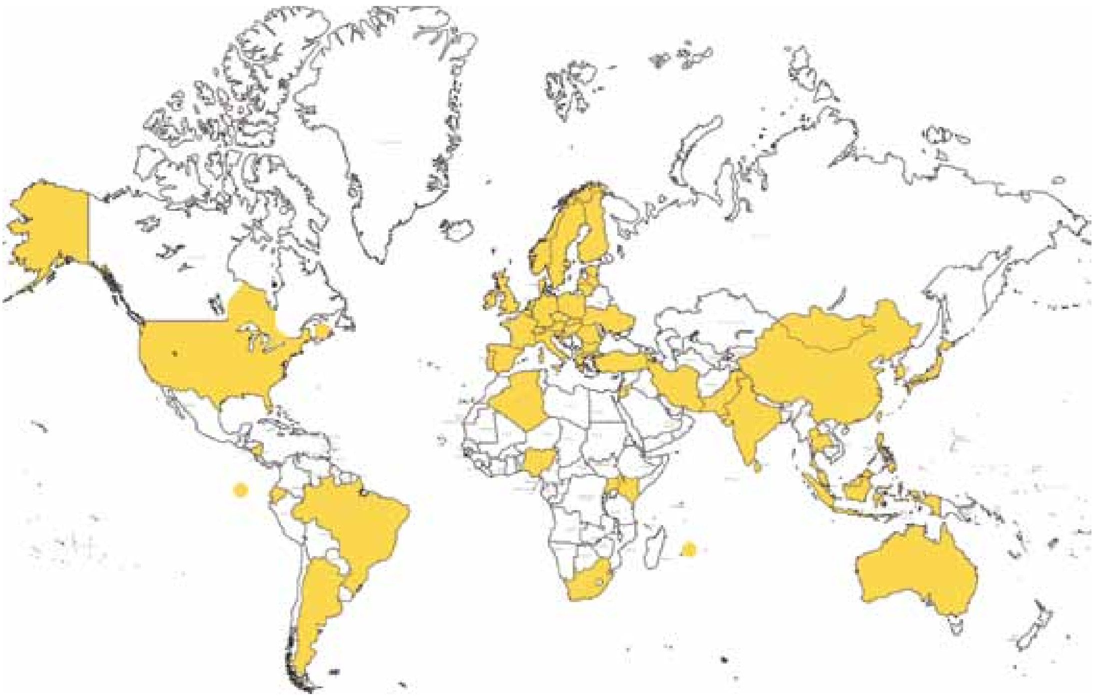
Energy Efficient Mortgages (EEMs) or Energy Improvement Mortgages (EIMs), often referred to as “green mortgages”, are loans which provide the borrower with lower interest rates or a bigger loan than normally permitted as a reward for making energy-efficient improvements or for buying a home that meets energy-efficiency standards.

One of the prerequisites for the introduction of "green mortgages" is the existence of nationally recognized energy performance standards. The economic rationale behind green mortgages is that energy-efficient homes will save money for the home-owner, resulting in a higher income which qualifies the beneficiary to borrow more (UNEP SBCI, 2009a). A case study in green mortgages is detailed in Section 3.5.5.

Feed-in tariff (FIT), advanced renewable tariff, renewable energy payments

Regulatory targets are usually complemented by price-based instruments such as feed-in tariffs. Governments require their energy utilities or suppliers to purchase electricity from private suppliers at a rate set by the government, preferably higher than that paid for electricity generated from conventional sources. By 2009 the total number

FIGURE 3.1 COUNTRIES OR TERRITORIES CURRENTLY WITH OR PREVIOUSLY HAD FIT PROGRAMMES IN PLACE



UNEP SBCI, 2009a; REW, 2009; PVTECH, 2014; Seppälä, 2014.

of countries with feed-in tariffs was 45; states/provinces/territories at 18. Figure 3.1 shows the countries and territories which have implemented feed-in tariffs. Municipal and local governments can also and have introduced feed-in tariffs at the local level (UNEP SBCI, 2009a).

Of the major energy producers and consumers in the world, China's 2005 Renewable Energy Law stipulates that 10 per cent of total power consumption should come from renewable sources by 2020, while the EU has set an even more ambitious target of 20 per cent by 2020. While the US and Canada do not have national targets, states and provinces currently have their own policy targets on renewable energy. Renewable energy markets have also been boosted by the enactment of Renewable Portfolio Standards (RPS) in several major energy consuming countries, notably the United States. These consist of electricity generation requirements, imposed on electric utilities by state legislatures, to provide either a specific amount of electric capacity or a percentage of total capacity from renewable sources. Utilities can also purchase renewable energy credits from external sources to fulfil these obligations. As of early 2009, 9 countries had enacted national RPS policies, while 29 U.S. states, 3 Canadian provinces, 5 Indian states and Wallonia and Flanders in Belgium had introduced RPS at the state/provincial level. Although the transaction costs of these schemes are initially high, and advanced institutional structures are required, Renewable Portfolio Standards enable the establishment of a marketplace for trading certificates and thus provide a tangible incentive for investments in renewable energy (UNEP SBCI, 2009a).

Combinations of policy instruments and barriers to their implementation

In almost all cases, policy targets are best achieved through a combination of instruments, or policy packages, rather than one or two policies implemented alone. Furthermore, there may be overlap between the policy targets, for example, promoting investment in energy efficiency measures and changing consumer behaviour. Decision-makers can 'mix-and-match' their policies to find the optimum solutions to fit particular carbon reduction goals (UNEP SBCI, 2009a).

Every policy measure has its own advantages, ideal target groups and specific operational mechanisms. Each is tailored to overcome one or a few certain market barriers, but none can address all the barriers. Thus, none of them can alone capture the entire potential for energy efficiency improvements even in a single location, nor can one instrument be singled out as a generally applicable best solution. In addition, most instruments achieve higher savings if they operate in combination with other tools, and often these impacts are synergistic, i.e. the impact of the two is larger than the sum of the individual expected impacts (IEA, 2005). Therefore, policies are rarely enacted in isolation, but rather as part of a complex policy framework.

A number of combinations of policy instruments are possible as illustrated in table 3.2. Usually, combining 'sticks' (regulations), and 'carrots' (incentives), with 'tambourines' (measures to attract attention such as information or public leadership programs), have the highest potential to reduce GHG emissions (Warren, 2007). Measures to attract attention can be information programs, but also simply choosing the right channels to reach citizens such as via energy suppliers as intermediaries (UNEP SBCI, 2007).

TABLE 3.2 A SELECTION OF POSSIBLE POLICY INSTRUMENT PACKAGES AND EXAMPLES OF COMMONLY APPLIED COMBINATIONS.

Measure	Regulatory instruments	Information instruments	Financial /Fiscal Incentives	Voluntary Agreements
Regulatory instruments	Building codes and standards for building equipment	Standards and information programs	Building codes and subsidies	Voluntary agreements with a threat of regulation
Information instruments	Appliance standards and labelling	Labelling, campaigns, and retailer training	Labelling and subsidies	Voluntary MEPS and labelling
Financial/Fiscal Incentives	Appliance standards and subsidies	Energy audits and subsidies, Labelling and tax exemptions	Taxes and subsidies	Technology procurement and subsidies
Voluntary Agreements	Voluntary agreements with a threat of regulation	Industrial agreements and energy audits	Industrial agreements and tax exemptions	

Note: *MEPS (Minimum Energy Performance Standards).*
Adapted from IEA, 2005.

Barriers

A significant barrier for promoting sustainable alternatives through voluntary action is the lack of confidence about the real benefits of green buildings to individual homeowners. Another closely linked deterrent is the additional initial investment required. Energy and water efficiency and conservation still remains a low priority for individual homeowners of social housing projects, since energy and water consumption and associated cost per household is less compared to typical houses. Lack of information is another barrier. Stakeholders such as developers and financiers could benefit from performance data for decision making.

A wide range of barriers in the markets, technologies, end-user demand, building design, construction, and operation, as well as in the purchase and use of appliances can impede the reduction in emissions. The most important barriers that pertain to buildings are discussed below (Boardman, 2007; Creyts, et al., 2007; Planning Commission, 2005; Urge-Vorsatz, et al., 2007a).

TABLE 3.3 TYPES OF IMPLEMENTATION BARRIERS

Barriers	Description
Financial	Upfront costs of products
Hidden Costs	Time costs; 'transaction costs' with providers; quality of product/cost differences; Information about suppliers
Lack of Information	Household knowledge on their level of energy expenditure and regarding how much, and at what cost (investment), energy can be reduced.
Risks and uncertainty	Unsure of savings due to uncertainty on future energy prices
Poorly aligned incentives	In rental market, tenants have no incentive to reduce their energy use as their landlord covers the energy bill
Psychological/ sociological	Habit and late adopter mentality
Regulatory	Some regulations cause difficulties for households to benefit from or consider energy efficient measures.

Gupta & Chandiwala, 2012.

Possible barriers are (Urge-Vorsatz, et al., 2007b):

- Financial - higher initial costs, hidden costs and benefits not directly captured in financial flows
- Market - failures might arise when policies or incentives not translating into actual benefits
- Behaviour – lack of incentives/barriers to change behaviour/ life style choices which hinder

The Carbon Trust in the UK classifies these barriers into four main categories:

- real market failures;
- financial costs/benefits;
- behavioural/ organizational; and
- hidden costs/benefits (The Carbon Trust, 2005).

Further classification of key barriers are summarised in table 3.3 below.

Given these barrier descriptions, table 3.4 below summarises the range of policy instruments to overcome major barriers to implementation.

TABLE 3.4 THE RANGE OF POLICY INSTRUMENTS TO OVERCOME MAJOR BARRIERS TO IMPLEMENTATION

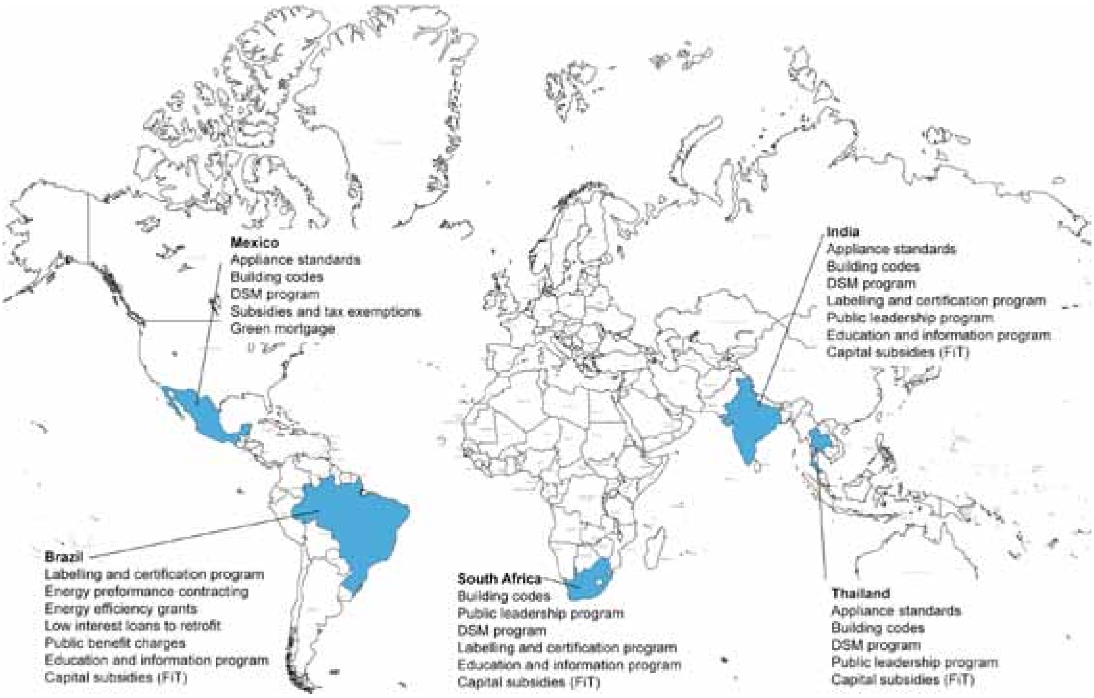
Barrier Category	Instrument Category	Policy Instruments as Remedies
Economic Barriers	Regulatory- normative/ regulatory informative Economic Instruments Fiscal Instruments	Appliance standards, building codes, energy efficiency obligations, mandatory labelling, procurement regulation, DSM programs EPC/ESCOs, Cooperative Procurement, Energy Efficiency Certificates Taxation, public benefit charges, tax exemptions, subsidies/ rebates/ grants
Hidden Costs/ Benefits	Regulatory-normative Economic instruments Support action	Appliance standards, building codes EPC/ESCOs Public leadership programs
Market Failures	Regulatory-normative/ regulatory informative Economic instruments Fiscal instruments Support, information, voluntary action	Appliance standards, building codes, energy efficiency obligations, mandatory labelling, procurement regulation, DSM programs EPC/ESCOs, cooperative procurement, energy efficiency certificates, Kyoto flexibility mechanisms Taxation, public benefit charges, tax exemptions, subsidies/ rebates/ grants Voluntary labelling, voluntary agreement, public leadership programs, awareness raising, detailed billing
Cultural/ Behavioural Barriers	Support, information, voluntary action	Voluntary labelling, voluntary agreement, public leadership programs, awareness raising, detailed billing
Information Barriers	Support, information, voluntary action Regulatory/informative	Voluntary labelling, voluntary agreement, public leadership programs, awareness raising, detailed billing, mandatory labelling, procurement regulations, DSM programs, mandatory audits
Structural/Political	Support action	Public leadership programs

Kumar, 2009; Creyts, et al., 2007; The Carbon Trust, 2005; Urge-Vorsatz, et al., 2007a.

Emerging best practice in promoting greening of the social housing sector at the legislative/policy, institutional, financial and technical levels

The following five subsections present the policy findings for South Africa, India, Brazil, Thailand and Mexico (figure 3.2). The case studies describe effective policy instruments (described above) which are either implemented or in planning stages.

FIGURE 3.2 POLICY CASE STUDY LOCATIONS



South Africa

68 per cent of South Africa's 12.5 million dwelling units comprise formal housing while the rest is made up of backyard properties, informal and squatter units (Ziuku and Meyer, 2011). The Department of Housing in South Africa has produced 2.4 million houses in the past 12 years before 2011. This is considered a significant achievement since for the first time in the history of the country the housing backlog figure is lower than the number of houses produced. In contrast, there is little evidence of affordable land and housing in other Sub-Saharan countries; housing

programmes either do not exist, are not affordable, or are insufficient to meet demand (UN-Habitat, 2011b). Historical trends and anticipated growth from government investment programmes are expected to increase investment in residential and non-residential buildings by around 2 per cent per year between 2008 and 2050 which would result in the total building stock doubling by 2050. If CO_2 emissions were left unchecked, this would result in a twofold increase in emissions.

The most prevalent type of dwelling unit is a house or brick structure on a separate stand or yard, which reflects a historic preference of homeowners for this type of unit. There has, however, been a trend away from this preference over recent years as homeowners have increasingly appreciated the benefits of living in flats, townhouses and cluster units (UNEP SBCI, 2009b).

For South Africa, change in the building sector is complex, due to:

- **Fragmentation of the building sector:** There is limited interaction and co-ordination between stakeholders sectors (architecture, engineering, building management, building function, occupants etc.) across the various life cycle stages of a building resulting in a lack of incentive for a life-cycle approach to managing energy use in buildings.
- **Split economic interests:** Decisions on building design are often made by parties (designers and investors) who do not directly benefit from improvements in energy-efficiency and reduction in associated costs.
- The lack of evidence and risk-benefit analysis of real projects expounds the **perceived business risk associated with investments in the energy efficiency of buildings.** Underestimation of life-cycle cost benefit is also common.
- **Energy costs are often a comparatively small part of the overall costs for a building:** Currently reduced energy bills provide a weak economic incentive especially since building costs occur over a short period while energy costs are spread over the lifetime of the building.

Policy Assessment

The major opportunities for energy efficiency in the residential building sector in South Africa have to date tended to focus on solar-water heating, geyser blankets, space heating efficiency, energy efficient lighting and behaviour change. Collectively, it is estimated that these opportunities could result in energy efficiencies in new buildings of around 30% to 40% in the residential sector. Several policy instruments and initiatives that focus on the boost of these opportunities in the building sector are being developed and implemented in South Africa, most notably: demand-side management initiatives; guidelines for energy-efficient buildings (SANS 204); building rating systems (Green Star SA); and retrofitting of government buildings (table 3.5).

- Some of the common opportunities for energy efficiency in green buildings both in commercial and residential sector include solar-water heating and changing occupant behaviour.
- Other policy mechanisms such as tax exemptions/ reductions, which work effectively internationally, are not being considered in South Africa at present.

- A few of the policy instruments, identified in the National Energy Strategy of South Africa, have not yet been implemented such as: appliance standards, mandatory audit requirement; and labelling and certification programmes

In general, there is a much discussion around the need for policies and best practices to be implemented in the building sector, but this has not been converted into concrete actions due to financial and capacity constraint; and large amounts of time scales required for implementation. Though limitations exist, the significant need for action to address climate change and energy efficiency is well recognised in the public and corporate sectors, and there are many examples at national, provincial and local level where the public sector is beginning to demonstrate leadership. The challenge, however, remains translating intent into action.

TABLE 3.5 BEST PRACTICE POLICY INSTRUMENTS AND STATUS IN SOUTH AFRICA

Assessment of Energy Efficiency/GHG Emission Reduction Policies			
Policy instrument	**Emission Reduction Effectiveness**	**Cost-Effectiveness**	**South African Status**
Appliance standards	High	High	Not readily available in SA, no requirements in place.
Energy-efficiency obligations and quotas	High	High	National draft recommendations in place.
Demand side management programmes (DSM)	High	High	National DSM programme in place but constrained by finance.
Tax exemptions/ reductions	High	High	Under consideration.
Cooperative procurement	High	Medium/High	No requirements
Building codes	High	Medium	SANS 204 currently only voluntary and could take up to three years to be mandatory. Will only specify minimum standards and only applicable to new buildings.
Mandatory audit requirement	High, but variable	Medium	No requirements in place.
Energy performance contracting (EPC)/ESCO support	High	Medium	Limited use for public-sector retrofitting but stopped due to irregularities.
Capital subsidies, grants, subsidised loans	High	Low	Very limited.
Labelling and certification programmes	Medium/High	High	Voluntary certification in place (e.g. Green Star SA, based on the Australian system and customised for South Africa), with mandatory requirements for public buildings under consideration.

Public leadership programmes, incl. procurement regulations	Medium/High	High/Medium	Public leadership growing, often constrained by finance, capacity or regulatory obstacles.
Voluntary and negotiated agreements	Medium/High	Medium	Energy-efficiency agreements in place amongst industry and public sector, progress somewhat limited.
Public benefit Charges	Medium	High	Not in place.
Energy-efficiency certificate schemes/white certificates	Medium	High/Medium	Not in place.
Detailed billing and disclosure programmes	Medium	Medium	Not in place.
Education and information programmes	Low/Medium	Medium/High	Limited.
Kyoto Protocol flexible mechanisms	Low	Low	Some progress.
Taxation (on CO_2 or fuels)	Low	Low	Under consideration.

UNEP SBCI, 2009b.

The following are policies and legislation set to reduce GHG emissions with direct bearing on the housing sector in South Africa:

- White paper on energy policy for Republic of South Africa, 1998: served to increase electrification of households while encouraging energy efficient housing design.
- Construction industry development board act 38, 2000: aimed at determining and establishing best practice that promotes positive safety, health and environmental outcomes. All construction contracts above a prescribed tender value will then be assessed for compliance with best practice standards and guidelines published by the Board.

In 2006, the South African Cabinet commissioned a process to examine the potential for mitigation of South Africa's GHG emissions. Long Term Mitigation Scenarios (LTMS) are aimed at providing a strong scientific base to inform the Cabinet in the creation of a long-term climate policy. These scenarios for the residential sector set percentage reduction goals for the following measures: solar water heating, water tank insulation, insulation measures for space heating reduction and efficient lighting (UNEP SBCI, 2009b).

Regulatory and control policy

In addition there is the **South African National Standard (SANS)** 204 for energy efficiency in buildings. Residential houses need to comply with SANS 204-2 which specifies requirements for, amongst others, the following: orientation requirements, minimum R-value for building elements, permissible air leakage levels, hot water services, and mechanical ventilation and air conditioning (SABS, 2011).

A green building rating system, **Green Star SA** has been developed for South Africa, adopted from the Australian model and adapted to suit South Africa. Like the Australian rating system, it is a voluntary standard for various building types based on an assessment of environmental design categories.

Voluntary action: leadership

Government building retrofit initiative is being driven by the Department of Minerals and Energy (DME) in conjunction with the Department of Public Works (DPW), in line with the DME's energy-efficiency strategy in which government will lead by example through raising energy-efficiency awareness and by implementing specific measures within its own estate. A target for energy-demand reduction of 12% (of projected energy consumption) is to be met by 2015 (UNEP SBCI, 2009b). Leading by example is considered to be effective in creating awareness for green building materials and methods.

Energy Efficiency Demand Side Management (EEDSM) Initiative: The focus in the residential sector is for energy-efficiency savings. The residential sector offers the best opportunities to quickly roll out low-cost/ high-impact technologies (e.g. CFLs). Some of the current DSM initiatives include: the mass replacement of incandescent light bulbs with energy-efficient CFL light bulbs and smart metering.

Case study in South Africa

Cape Town Solar Water By-Laws: The City of Cape Town has adopted an Energy and Climate Change Strategy in which one of the goals is to have 1 million solar water heater (SWH) systems installed by 2014. To achieve this target the city is engaging in a number of initiatives, 1) Solar water Heater Bylaw: A subsidisation scheme, to assist staff below a certain income level to fit a SWH in their home; 2) project to fit SWHs to the city's nature reserve facilities; 3) provide support to the service providers to help overcome the market failures that prevent mass uptake of solar water heaters; and 4) Solar water heaters have been promoted through a national rebate scheme. The solar water heater programme has the potential to boost local economic and industrial development with the creation of sustainable jobs (Phakathi, 2012).

India

India is now a key global economic and political player and its developing economy is shifting towards the service sector, creating an upwardly mobile urban middle class. The Indian construction industry has an annual growth rate of 9.2% compared to the global average of 5.5%. Current trends project that 40% of India's population will be living in cities by 2020, in contrast to 28% in 2008 (McNeil, et al., 2008). The second largest energy consumer in India is the building sector and building energy use is increasing by over 9% annually, while the national energy growth rate is far lower at 4.3% (USAID and LBNL, 2006). An element to India's success in affordable housing provision is through a variety of policy mechanisms linked to a large quantity of publicly owned land. Though there is success, India has around 109 million slum dwellers (UN-Habitat, 2011c).

Electricity, oil, coal, biomass and gas are India's key end-use energy products; the building sector mainly consumes electricity (for appliances, heating/cooling and lighting) and gas/biomass/oil (for cooking). Primary energy sources for electricity are dominated by coal which is used to produce 71% of total electricity while hydro power produces 14%, natural gas 8%, and diesel and nuclear each represent 3% (De la Rue du Can et al., 2009). Since the building sector (domestic and commercial) accounts for approximately 33% of electricity consumption and is the fastest growing sector, it is critical that policies and measures are put in place to improve energy efficiency in both new construction as well as existing buildings. In fact it is estimated that 70% of the building stock in the year 2030 is yet to be built - a situation that is fundamentally different from developed countries such as the UK and US (Kumar, et al., 2010).

Policy Assessment

The Indian building sector is moving towards controlling its GHG emissions, without compromising on its development objectives, through a series of policy and market instruments. Activities have been undertaken to provide a policy framework for national energy conservation activities, disseminate information and knowledge, facilitate capacity building, pilot demonstration projects and establish energy efficiency delivery systems through public-private partnerships (ABPS Infrastructure Private Limited, 2009).

Key policy interventions:

- Provide energy use information: labelling of appliances, energy use information by units within industrial sectors
- Mandate standards: building codes, sectoral energy consumption norms in industry, market mechanisms to promote energy efficiency in industry
- Reduce perceived risk: market transformation and demand side management, performance guarantee contracting
- Incentives: differential taxation, preference in government procurement

The Indian Ministry of Housing and Urban Poverty Alleviation (MoHUPA) has developed several programmes that aim to increase affordable housing supply and improve existing slums. In the private sector, however, one issue in affordable housing provision is that there is a lack of lower-income finance options. Without finance private developers are unable to sell low-cost housing units which they are able to produce. Some states in India require a percentage of a private development to be allocated to the Economically Weaker Section (EWS), Haryana for example, requires 20 per cent of total plots in order to obtain a development licence (UN-Habitat, 2011c).

Table 3.6 illustrates policy instruments which have been applied to the Indian building sector.

TABLE 3.6 POLICY INSTRUMENTS

Policy instruments	India
Control and Regulatory Instruments	
Building codes	Energy Conservation Act 2001 Energy Conservation building codes (ECBC)
Appliance standards	National energy labelling programme for appliances
Mandatory demand-side management (DSM)	Bachat Lamp Yojna (Lamp Savings Project) — Provide CFL's at a reduced price)
Economic and market-based instruments	
Energy performance contracting	Six government buildings used ESCOs to carry out retrofits through performance contracting
Kyoto Protocol flexible mechanisms	Clean Development Mechanism projects -allowing industrialised countries to invest in emission reduction projects in developing countries as an alternative
Financial Instruments	
Capital subsidies grants, loans	Rajiv Gandhi Gramin Vidyutikaran Yojna States to distribute free CFLs to below poverty line families.
Information and Voluntary Instruments	
Voluntary certification and labelling	TERI- GRIHA; LEED– India
Public leadership programs	Energy audits and retrofit of buildings Central and State government buildings
Awareness raising, education, information campaigns	USAID – ECO III Manuals and codes, case studies and software. School programme National campaign on Energy conservation 2005 Award scheme for government and commercial buildings
Mandatory audit and energy management requirement	Designated industries to have energy managers, Certification and training of energy auditors
Detailed billing and disclosure programs	Bills are based on individually metered buildings as a norm.

Gupta & Chandiwala, 2012.

Regulatory policy

Energy Conservation Building code 2007

In 2007, the Energy Conservation Building Code (ECBC) was launched by the Bureau of Energy Efficiency (BEE), Government of India, for commercial buildings with peak demand in excess of 500 kW or connected load in excess of 600 kVA. It is expected that ECBC-complaint commercial buildings will experience energy savings of 27-40% over typical buildings consuming over 200kWh per square meter (UNEP SBCI, 2010a). The ECBC aims to restrict energy consumption in certain areas through: appliance standards and labelling; industrial energy benchmarks; monitoring energy use in high energy-consumption units; and certifying and accrediting energy auditors and energy managers.

In addition, specified energy intensive industries (labelled as Designated Consumers) are required to follow the protocol for energy management through: appointing or designating energy managers; energy audits conducted by accredited energy auditors; implementing techno-economically viable recommendations; complying with energy norms; and submitting report on steps taken. Enforcement of policy regulations and regular inspection of properties will become more crucial.

Educational programs, workshops and certification for stakeholders from the construction industry (designers, builders, technicians, suppliers and labourers) are found to be in need of mandatory status to create a skill base capable of sustaining/supporting the required green growth. In response, extensive training of architects, engineers and consultants is also being undertaken by BEE across India.

Voluntary instruments (Market side)

The National Action Plan on Climate Change released in 2008, introduced four new initiatives through the National Mission on Enhanced Energy Efficiency (BEE, 2009):

- Tradable Energy Savings Certificates, a market based mechanism to increase the uptake of cost effective energy efficiency improvements in energy-intensive industries and facilities. (Perform Achieve and Trade)
- Accelerating the shift to energy efficient appliances through innovative measures to make the products more affordable. (Market Transformation for Energy Efficiency)
- Creation of mechanisms that would help finance demand side management programmes in all sectors by capturing future energy savings. (Energy Efficiency Financing Platform (EEFP))
- Developing fiscal instruments to promote energy efficiency namely Framework for Energy Efficient Economic Development (FEEED)

Outreach (education and awareness) (ABPS Infrastructure Private Limited, 2009):

- Industrial units recognised for energy-efficiency activities through high-profile awards program
- National energy-conservation painting competition draws participation from over 400,000 children

Comparative Evaluation of Building Energy and Environmental Rating Systems

The two primary domestic rating systems in India are the indigenous Green Rating for Integrated Habitat Assessment (GRIHA) and LEED-India system adapted from LEED-USA. The Bureau of Energy Efficiency has also developed its own rating system the Energy Performance Index (EPI) aimed at office buildings.

GRIHA — Green Rating for Integrated Habitat Assessment is India's own system developed by the Energy Research Institute (TERI) and the Ministry of New and Renewable Energy, Government of India. It can be used to assess offices, retail spaces, institutional buildings, hotels, hospital buildings, healthcare facilities, residences, and multi-family high-rise buildings, and was first launched in 2007. It is closely linked to the requirements of ECBC. GRIHA considers building life cycle in four stages: Pre-construction, Building planning and construction stage, Building responsiveness to global and local environment and Building operation and maintenance stage (Majumdar and Kumar, n.d.). GRIHA:

- Addresses environmental concerns holistically
- Incorporates all relevant Indian codes and standards
- Applicable to residential, commercial and institutional buildings
- 100 point system with a set of 32 criteria of which some are mandatory
- Minimum qualifying points is 50 and rating given as 1-5 star from 50-100 points
- Addresses sustainable site planning, health of labour during construction, water consumption, embodied energy (materials), energy use, renewables, waste management, and occupant health.

The second rating system, **LEED-India** has been developed by the Indian Green Building Council. Though adopted, LEED-India has been adapted to suit India. Like the US rating system, it is a voluntary standard in India and awards four rating types of Certified, Silver, Gold and Platinum based on an assessment of six environmental categories (Gupta & Chandiwala, 2012).

A strong policy mandate at the local level to enforce compliance with GRIHA or LEED rating systems are found to be essential for progress. Priority sectors where maximum reduction potential exists must be targeted through policy and regulations. Additionally, financial incentives will provide the much required push to move away from unsustainable building design and construction practices, which are progressively entering into practices of building in the cities of India (UNEP SBCI, 2010a). Further research and development into local design, construction and materials suitable for local climates and resources will help bridge the existing knowledge and dissemination gap.

Barriers

The perceived notion of high initial incremental costs for green buildings, lack of financial incentives and the unorganised nature of the Indian construction industry are some of the most critical barriers to the adoption of green building guidelines (Potbhare et. al., 2009). Lack of reliable, free, public sources of information and advice on energy savings, suitable technologies and sustainable building choices were also identified as significant barriers.

Case study in energy efficient lighting

The Bachat Lamp Yojana (Lamp Savings Project) was launched in 2009 as a demand side management initiative. The project is a public-private partnership between the Government of India, private sector CFL suppliers and State level Electricity Distribution Companies to provide compact fluorescent lights (CFL) to households at the price of incandescent bulbs. The difference in cost is recovered through the carbon credits accrued from lower energy use; managed and supported by the electricity distribution companies.

Brazil

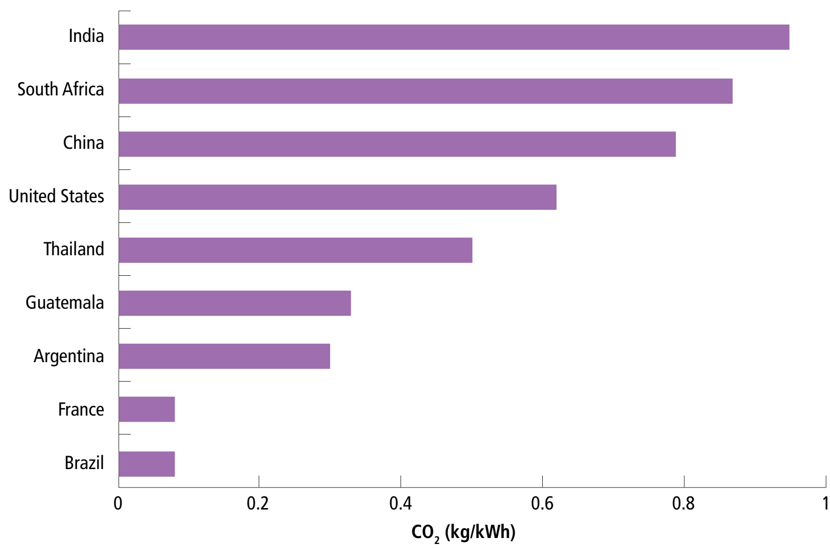
Brazil has undergone substantial urbanization since the nineteen forties, leading the country to attain an 80 per cent urbanization rate by 2000 (UN-Habitat, 2013b). Within this context, informal submarkets and household self-help initiatives are estimated to account for approximately three-quarters of all housing production between 1964 and 1986. The Brazilian housing deficit was estimated to be the equivalent of 15 per cent of the housing stock in 2005. 81 per cent of this deficit is in cities (UN-Habitat, 2011d).

Brazil is the world's tenth largest energy consumer and third in the western hemisphere, behind the USA and Canada. Sustained economic growth has increased total primary energy consumption by close to a third over the last decade (EIA, 2012). Compared to the rest of the world, Brazil has a relatively clean energy matrix: 47 per cent (including the use of fossil fuels for transportation) are considered renewable sources (primarily hydroelectric and ethanol) whereas only 20 per cent of the world's resources are considered renewable (Lamberts, 2008). Mostly due to the predominance (80%) of hydroelectric electricity generation, figure 3.3 shows that Brazil is one of the countries with the lowest CO_2 emission per kWh of electricity generated, among other case study countries: India, South Africa, and Thailand (MME, 2008). The remainder is divided into thermo-electric coal, natural gas, fuel oil, diesel oil, nuclear power plants and plants using other materials as energy, such as firewood and sugarcane (John, et al., 2010).

Policy instruments

In Brazil, the energy shortages of 2001 and the resulting 20% mandated reduction of energy use as well as the ensuing energy crisis are often described among the most important drivers for the introduction or success of energy efficiency

FIGURE 3.3 CO_2 EMISSIONS FOR GENERATION OF ONE KWH OF ELECTRIC ENERGY



WRI, 2009

programs such as the labelling programs implemented (UNEP SBCI, 2007). The key players in energy efficiency measures are the parastatals, contractors and/or Energy Services Companies (ESCOs), financial institutions, the local community, the government and non-profit groups. Promotion of energy efficiency measures is done by the two main parastatals, Electrobás and Petrobás (Brazil Country Report, 2006). Examples of government programmes undertaken by these parastatals are PROCEL (Policy to combat waste in the production and use of electrical energy) piloted by Electrobás, and COPET (conservation program for oil and gas including measures to upgrade operating procedures, optimise distribution, prevent leaks and spills etc.) piloted by Petrobás (Keivani, et al., 2010).

The main green housing initiatives for social housing in Brazil are water heating, thermal comfort projects, labelling, solar energy and the selection of low-energy materials. Unfortunately, however, financial institutions are reluctant to fund energy efficiency projects.

Regulatory policy instruments

Labelling programmes and performance standards are capable of reducing consumer energy demand by increasing awareness about energy efficiency of different products and creating a competitive environment where manufactures are compelled to improve their products. The ability of producers to adapt to market demands often prevents consumer prices from going up in what is described as the "learning effect". Experiences and proven models from labelling programs in OECD countries have shaped the programs introduced in developing countries. The European label for energy efficiency standards (e.g. for refrigerators and freezers) is used in Brazil (World Energy Council, 2008). Through the application of specific policy measures such as labelling programmes and economic incentives, sustainability is recognised in Brazil's case as a win-win for families, government, construction companies, materials industry, workers, financial system and society as a whole.

Fiscal policy instruments

Energy pricing – Despite current Brazilian home energy prices being among the highest in the world there are indications of tariff increases, especially in the electricity sector (Júnior, et al., 2003). Persistent distortions in the structure of regulated electricity prices (Júnior, et al., 2003; Brazil Country Report, 2006; and Poole and Guimarães, 2003) have had resultant distortions in corporate investment in energy rationalisation, making energy efficiency improvements a low priority (Poole and Guimarães, 2003). Electricity tariffs need to be based on detailed studies and include incentives for sustainable building projects.

Even with cost-reflective (not subsidised) energy prices, the higher first cost of energy efficient technologies may still limit their use in developing countries, especially if the technologies have to be imported. In Brazil, to face this challenge, there are public benefits charges (a form of energy tax whose revenues are typically invested partially or completely into energy efficiency). This is a mechanism for raising funds from the operation of the energy market, which can then be directed into demand side management (DSM) and energy efficiency activities. All Brazilian distribution utilities are required to spend at least one per cent of their revenues on energy efficiency improvements, while at least one quarter of this amount (representing approximately $50 million per year) has to be spent on end-use efficiency projects (UNEP SBCI, 2007).

Subsidies, Incentives and tax reduction - Financial institutions are typically reluctant to fund energy efficiency projects. Since the relative size of ESCOs inhibits their funding capacity, government assistance will play an important role in stimulating the energy efficiency market (UNEP SBCI, 2007).

Subsidies are proven to be helpful in the residential sector in order to overcome the major barrier of high first costs for sustainability measures (e.g. to help poor households to engage in energy efficiency investments). In Brazil, the National Electrical Energy Conservation Program (PROCEL) provides grants to state and local utilities, state agencies, private companies, universities and research institutions. PROCEL is in place to tackle waste in the production and use of electrical energy. Measures include:

- Consumption labelling to inform consumers, influence purchasing decisions and encourage manufacturers to make efficient products;
- Energy diagnostics/audits to assess energy use and efficiency;
- Supporting research and development of efficient technologies/products;
- Replacing incandescent lamps in public lighting with lamps that consume less energy;
- Promoting efficient lighting and appliances in government and residential buildings;
- Measures to reduce losses in the electrical system;
- Actions to reduce electricity demand during peak hours;
- Training courses, seminars, and conferences to industrial and commercial consumers, concession-holder staff and public organizations to tackle energy waste

PROCEL also helps utilities obtain low-interest financing for major energy efficiency projects from a revolving loan fund within the electric sector (WRI, 2013). These grants and the measures pursued resulted in cumulative savings of 5.3 TWh (169 ktCO_2) per year at a benefit-cost ratio of 12:1 from 1986 to 1998 (UNEP SBCI, 2009a).

Information awareness

Policies which raise public awareness and reveal the advantages of energy efficiency projects will play a key role in triggering the acceptance and growth of energy efficient refurbishment projects. The cost-effectiveness of information programmes exceeded those of most other policy instruments, with negative costs of \$66/tCO_2. Public information campaigns include programmes which provide “energy tips” and counselling, energy consumption feedback and assessments, elementary school programs, and mass media motivational campaigns. They are often more effective for the residential than the commercial sector. Information programs are especially important in developing countries, where a lack of information has been identified as a major barrier for energy efficiency and renewable energy investments (UNEP SBCI, 2009a). In order to be effective, public information campaigns have to be adapted to the audience, deliver a credible and understandable message, which influences audience beliefs, and finally create a social context that leads to the desired outcome. There are also positive experiences with public leadership programmes in Brazil (UNEP SBCI, 2007). These programmes serve to educate, influence and demonstrate effective measures and results. Brazilian practice (through the UNEP funded SUSHI project) has also shown to some degree that life cycle analysis is regarded as an important tool for the selection of energy efficient products/ materials.

Multi-unit low-income housing and political interest: The Centre of Projects for the Built Environment facilitated a project of high-quality multi-story housing units for approximately 5000 low-income families in São Paulo, Brazil between years 1990-2007. The project included people in all stages of the building process, provided the people with skills, enhanced women's positions and increased the knowledge of local governments about the importance of the social aspects in housing.

Sustainability project teams worked with housing developers, construction companies, financial institutions and final users to identify sustainable solutions available on the market and applicable to the local context, with the main objective to identify, map out and characterise essential technologies suitable for social housing units in Brazil considering all relevant stakeholders. The solutions were selected to improve the energy efficiency (including provision of thermal comfort) and water efficiency (water supply and consumption) of social housing units. To technically back up these options, in cooperation with the State of São Paulo's Housing and Urban Development Agency (CDHU) and Brazilian Sustainable Construction Council (CBCS) and with technical support from universities in Brazil, the project team, developed an analysis of lessons learned from previous experiences in integrating sustainable features (e.g. alternative design solutions, solar water heaters, and individual water meters) in homes.

A pilot site in Cubatao in the state of Sao Paolo was used as a reference to develop market analysis, to identify key elements in the project agenda, and to define pilot functions and alternative solutions. Considering the Brazilian energy matrix, project location, client income and needs, and cultural characteristics, the local agenda was developed to define pilot functions of the project. The conclusions led to the elaboration of recommendations for the uptake of sustainable solutions with focus on rational use of water and demand management as well as thermal comfort and lighting, prevention of air conditioning use, and application of renewable energy strategies including solar heating. The team also worked with the Brazilian Federal savings bank -Caixa- to develop the criteria for a sustainable housing label that can be applied to affordable housing projects (UNEP, 2013). Similar projects in Brazil have led to an attitude change on the higher political levels. Public funds are now used to support housing for low-income households and in 2001, 'The city statute' was approved by the parliament followed by a Slum Action Plan by the Secretariat for Housing and Urban Development (UN-Habitat, 2012a).

World Habitat - Building Restoration for Social Housing Purposes: Derelict commercial buildings in São Paulo's city centre were recycled and converted into low-income housing as part of this project which reversed a ten-year tendency of exodus from the area and making use of its urban infrastructure. This is the very first project in the Brazilian national housing programme to involve a change of use from commercial to residential. The former air-conditioned and electrically lit systems were replaced with natural ventilation and daylight provisions. The project was financially supported by the City government and the Federal Savings Bank and involved the residents in decision-making, discussion, design process, planning and management of the project. Further detail on this case study is provided in Section 5.

Thailand

The Kingdom of Thailand in Southeast Asia is an emerging economy and the world's 20th-most-populous country, with around 64 million people. Though Thailand's unemployment rate of less than 1% of labour force is among the lowest in the world (CIA, 2013), cities like Chang Mai have one of the highest rent-to-income ratios at 25:1 (UN-Habitat, 2011c). In Thailand, the primary energy source is oil and natural gas, and the main consumers are transport, industry and residential and commercial sectors. 70% of the electricity is produced from natural gas. In Thailand the residential and commercial sector consume 21% of primary energy and are the main consumers of energy in Bangkok (DEDE Annual Report, 2005).

Owner occupied, detached housing constructed of cement, wood or brick is the most prevalent housing solution, with 80% of Thai dwellings being owner occupied. Basic infrastructure is available to more than 95% of households with widespread availability of electricity, water, roads, and septic tanks. In rural areas, the Provincial Electricity Authority (PEA) provides households with solar electricity until their utilities are constructed (Sreshthaputra, 2010). Average household size is 3.5 persons and the average room per household is 2.8 rooms per household (Sreshthaputra, 2010). The Government Housing Bank (GHB) has played a leading role in the development of social housing in Thailand. In addition to National Housing Association (NHA), there are few private developers in the market. Prueksa Real Estate Plc., one of the largest privately owned real estate development companies, is also a key player in this sector.

Policy instruments

Like many developing countries with successful energy efficiency policies, Thailand started its sustainable development initiative with the adoption of energy efficiency laws and strategies. Thailand is considered a model for developing countries due to the countries' success in making energy efficiency a national priority through its energy conservation law and accompanying measures. Subsidies, effective in breaking the barrier of financial limitations for energy efficiency, are one component of the successful energy conservation law in Thailand, combined with mandatory energy audits, awareness raising and training as well as demonstration projects. Specific ministries, commissions or departments dealing with awareness and information on energy efficiency as well as energy agencies play an important role.

Thailand also has a successful demand side management (DSM) program combined with labelling. The energy efficient lighting (CFL) project and energy labelling programmes for refrigerators and air-conditioners have both been successful. Combination with other policy instruments such as fiscal incentives and regulation enhances their effectiveness. The DSM office pursued market transformation by stimulating the production and import of more efficient appliances and by encouraging consumers to buy these new products. This initiation of market transformation evoked the interest of foreign investors in the energy efficiency market (UNEP SBCI, 2007).

As with other examples in this report (e.g. Brazil), labelling programmes introduced in developing countries are based on the experience and proven models of OECD countries. The Australian label and model for energy efficiency standards (e.g. for refrigerators and freezers) is used in Thailand. Voluntary certification and labelling programs for appliances can be effective as well as cost-effective if designed well and updated regularly. This example of what is proven to work in both developed and developing countries is helpful for implementing labelling programmes in countries that do not have them (World Energy Council, 2008).

The Sustainable Social Housing Initiative (SUSHI) was initiated by the United Nations Environment Programme (UNEP) in May 2009 to increase the use of sustainable (resource-efficient and energy-efficient) building and design solutions in social housing programs in developing countries. This project provides methods and specific guidelines for developers to remove the barriers to the integration of sustainable solutions in the design, construction and operation of social housing units by testing such approaches in pilot sites - in Bangkok, Thailand and in Sao Paulo, Brazil.

In Bangkok social housing sustainability project teams worked with housing developers, construction companies, financial institutions and final users to identify sustainable solutions available on the market and applicable to the local context, with the main objective to identify, map out and characterise essential technologies suitable for social housing units considering all relevant stakeholders. The solutions were selected to improve the energy efficiency (including provision of thermal comfort) and water efficiency (water supply and consumption) of social housing units. Key stakeholder organisations included the NHA, the Community Organization Development Institute (CODI), the Bangkok Metropolitan Administration (BMA), and the Ministry of Energy some of which run most of social housing projects in Thailand.

After literature review, field study, consultations and analysis, two social housing projects of the NHA in Bangkok were selected as the project sites to develop site-specific guidelines, including a cost-benefit analysis for selected sustainable technologies. The identified alternatives were: passive design, improved glazing, wall and roof insulation as well as grey water recycling and reuse, applying efficient fixtures, and rainwater harvesting. Based on the findings, an action plan was proposed including different activities to enhance the uptake of alternative solutions in social housing sector in Bangkok. The team prepared policy and technical assessments to be used by relevant stakeholders. It also conducted several training programs on design and construction of sustainable buildings with local stakeholders and a consultation workshop for decision makers. Furthermore, a database of available sustainable alternatives was prepared for web-publication. Finally, to increase awareness of the role of sustainable buildings, the team developed an educational TV documentary and video that will be distributed in universities across the country. At a global level, the project defines a generic methodology for replication of sustainable building practices.

Sustainability was applied in a holistic manner to provide (UNEP, 2013):

- Quality of housing units (longer lifetime, less maintenance, less defects);
- Quality of life (healthier environment, well-being);
- Market opportunities (local products promoted, more sustainable materials);
- Reduced environmental impact and costs over the life cycle; and
- Urban planning and Social integration/interaction (no clusters).

In general, split incentives is a barrier hampering the uptake of green buildings. Project promoters may not have any incentive to incorporate energy efficiency and water efficiency in their projects, as they do not get paid back for their investments as the benefits would go only to the homeowners or tenants. Home owners and tenants have the same disincentive. This is not the case for NHA, being a government organization. They share the commitment of the Thai government to promote energy and water efficiency for the sake of national, regional and global benefits. Some of the national level benefits include the conservation of water and energy, easing of the pressure on civic infrastructure, human health benefits and avoidance/reduction of additional investments for infrastructure in the power and water sector. Global and regional benefits include the reduction of GHG emissions and the conservation of shared water resources (Sreshthaputra, 2010).

It is clear that a wide range of short and long term action is necessary to remove existing barriers and bring about a market transformation in favour of green buildings in the social housing sector in Thailand. Awareness raising activities have to be carried out using separate media routes for each target sector. The private sector would need appropriate incentives, especially during the initial phases of the market development process. Once the market develops, the private sector could energise the market transformation process, even with lesser government support. Efforts also need to be made to appeal to the Corporate Social Responsibility of the larger private sector corporations in this sector.

The SUSHI project in Bangkok, within its short time frame, aimed to work with partners, especially NHA, achieving the following, mainly within the ambit of the two identified pilot functions and their alternative solutions (Sreshthaputra, 2010):

- Assess the status of sustainable social housing in Thailand
- Initiate and institutionalise capacity building programmes in key organisations
- Increase awareness on green buildings among professionals and the public
- Provide essential tools and guidelines that could help professionals in developing and implementing social housing projects
- Provide policy guidelines for NHA, partner organisations and the government.
- Create long term associations among key organizations involved in the green building movement and the social housing sector in Thailand.

Mexico

Mexico is a federal territory formed by 31 states and a Federal District (Mexico City), and is divided into 2,446 municipalities. There are close to 200,000 populated locations in the country, of which only 178 have 50,000 or more inhabitants; in contrast, there are close to 150,000 populations with less than 100 inhabitants. Of the total population, only 23% live in rural areas, with the majority living in the southwest part of the country clustering around Mexico City (UNEP SBCI, 2010b). Informal submarkets and household self-help initiatives are estimated to account for more than half of all housing production between 1980 and 2003 (UN-Habitat, 2011d). According to CONEVAL (National Council on Evaluation of Social Development Policy) an estimated five million Mexicans lived in poverty in 2010. This implies that around 46.2% of Mexico's total population lives in poverty, mainly in urban areas. According to the 2006 national energy balance, final energy consumption of the residential sector represented 16% of the total final energy consumption in Mexico. Liquid petroleum gas (LPG) is the main energy source used in the residential sector at 37.8%, followed by firewood at 35%. Electricity contributed with 22.7% of the final energy consumption, natural gas 4.2% and kerosene 0.3% (UNEP SBCI, 2010b).

Policy instruments

There are no specific laws involving sustainable development priorities for buildings in Mexico. There are, however, a number of policies and programs involving both the government and the private sector that have direct and indirect impacts on the CO_2 eqv. emissions that result from residential and commercial buildings operations.

Mexico's federal government National Strategy on Climate Change

- Identifies specific measures for mitigation, with estimates of potential for emissions reductions
- Proposes a suite of research objectives as a tool for laying out more precise mitigation targets and outlines national requirements for capacity building for adaptation to climate change.
- Enforcement of policy and regulations need reinforcement at the state and local level.

Mexico City's Climate Action Program

- Large water conservation programs, public transportation and waste management projects, and subsidies and incentives for residential and commercial buildings.
- Tax exemptions for new and existing residential and commercial buildings that integrate energy and water conservation.

There is a clear need to economically support low-income families with energy subsidies. However this can send the wrong economic signal to the large proportion of the population who receive but do not require these subsidies. It is therefore recommended that funding mechanisms must be altered to reach only the neediest while other subsidies are re-directed towards promoting energy efficiency. Awareness about the advantages of Green Buildings must also be increased to maximise the impact of subsidies.

Greening the building sector

- Energy efficiency standards for appliances
- Energy efficiency standards for lighting systems and building envelope of non-residential buildings.

- CFE and FIDE´s DSM programs
- The Instituto del Fondo Nacional de la Vivienda para los Trabajadores (Institute for the National Workers' Housing Fund) (INFONAVIT) "Green mortgages" program.
- Comisión Nacional de Vivienda (CONAVI) Low Income Housing subsidies.
- Solar water heating standards
- Environmental regulation that mandate the use of solar water heating systems in non-residential buildings in Mexico City.

The building sector needs to become a government priority through specific laws supporting and guiding sustainable development. The current scope of DSM programs by CFE need to be widened beyond residential lighting and space cooling and Minimum Energy Performance Standards (MEPS) should be introduced for all equipment in the market. It is recognised through the example of Mexico, that to increase public awareness about green buildings and providing free accessible information and advice on energy efficiency will be the key to the progress of sustainable development.

Case study in a market based solution: Green Mortgage

Green Mortgage is a housing finance scheme developed by INFONAVIT to encourage the use of energy efficient systems and technologies for low-income households. Families purchasing homes with INFONAVIT are given an additional 'green' mortgage (a credit on top of the actual mortgage credit) of up to US$1,250 to cover the cost of additional low carbon technologies. The initiative aims to encourage developers to build homes with energy-saving materials and technologies, and the low-rate mortgage enables families to save more on their utility bills than the increase in their monthly mortgage payment. By 2012, over 900,000 Green Mortgage credits have been granted, benefiting over three million people.

The programme finances approximately 22 efficiency technologies that include:

- Electricity: energy-saving lamps, roof and wall thermal insulation, reflective coatings and voltage optimisation.
- Gas: gas and solar water heaters: with or without vacuum pipes, backup, etc.
- Water: ecological level toilets, ecological level sprinkler, water saving devices, isolating valves, flow control valves for water supply pipe.
- Health: purified water filters, purified water supply and waste separation containers.

Barriers to success

The lack of standards to regulate the quality and efficiency of the new eco-technology products has been a barrier for the project. In order to overcome this, INFONAVIT worked in partnership with regulators and suppliers to establish appropriate quality standards that achieve the necessary savings but which are still affordable.

The lack of education in the maintenance of equipment amongst users is being addressed through educational materials such as videos and comics.

The request for certification of products had to be done gradually in cases such as solar water heaters, where the laboratories responsible for testing did not had the capacity to meet the demand for equipment to be certified (WHA, 2012).

Summary

Overall work on green building is progressing in developing countries. Limitations still exist as they do in both developing and developed nations; these include financial and capacity constraints, awareness, first costs, etc., are common in a majority of situations and are overcome through policy measures covered throughout Section 3. From the countries analysed above, common barriers which need to be overcome more-or-less in each country are summarised as, but not limited to:

- First cost/ high perceived personal/ business risk associated with investment in the energy efficiency of buildings. Life-cycle cost benefit is often underestimated, not utilised.
- Lack of technical capacity in all stakeholder areas (architecture, engineering, building management, building function, occupants etc.). Sector training is essential.
- Limited interaction and co-ordination between stakeholders across the various life cycle stages of a building result in a lack of incentive for a life-cycle approach to managing energy use in buildings.
- Lack of user/ occupant education - in some cases users need to be aware of certain benefits to maximise those benefits.
- Tendency to develop standard regional and national solutions – without localised focus for every project (down to the site level) there is little integration of the climate, social and environmental considerations and the energy consumption, thermal comfort, water use, and health of the occupants.
- Incongruent economic interests - All stakeholders must have interest in the success of the green building or development.
- Energy costs – Reduced or unrealistic energy costs do not provide an economic incentive for change. Again life-cycle-costing awareness will also accentuate the true discrepancy.

Awareness-raising: There is a serious lack of awareness and of understanding about the impacts of the buildings sector and the costs and benefits of sustainable solutions and materials, and about the relevance of sustainable approach in social-housing projects (sustainability is perceived to be too expensive). There is a crucial need to raise awareness of costs and benefits of sustainable solutions in social housing units, as well as identifying the readily-available and low-cost market solutions. Awareness-raising must be conducted with all stakeholder groups, to understand which solutions might be appropriate to the budget, timing, site, and cultural characteristics of the project.

Technical training: Technical capacities are often missing to build sustainable units, among construction companies, architec ts, and workers in the buildings sector. Thus, there is a need for technical training of public officers and market actors to ensure understanding and capacity to implement sustainable technologies, as well as maintain these over the life of the building.

Building policy support: Costs and benefits of sustainable housing have to be clearly demonstrated and tested to make the case for policy support of sustainable social housing.

Financing opportunities: Some sustainable solutions result in a slight increase in the unit's construction cost. Financing opportunities and mechanisms to redistribute the costs and savings across the life-cycle of the building must be developed at local/national level to quantify the cost savings and other benefits associated with sustainable building approaches.

Defining stakeholders and their involvement and cooperation in sustainable approach: Projects often involve several different stakeholders at local and national level. Integrating sustainable solutions requires collaborative commitment of stakeholders to achieve the final objective, and understanding of different perceptions, needs and priorities. Stakeholders (identified through the SUSHI project, 2011) can include:

- National, state and municipal governments (policy development);
- Financing institutions (public bank, private banks, microcredit institutions);
- Public housing development agencies (procurers for social housing projects);
- Private housing and real-estate developers (project developers);
- Construction companies, architects, designers (project implementation);
- Users, inhabitants, associations (project implementation);
- Research centres and NGOs (project implementation);
- Material producers (supply of building materials).

Available information on successful examples: Policy makers and financing institutions need support in the form of examples and case studies and information from other constituencies to be able to initiate a review of relevant policies and to design supporting financing tools for sustainable social housing. Compilation of previous experiences, as well as measurement and monitoring of the impacts in case studies is crucial to ensure understanding and replication of sustainable alternatives.

Considering cultural and emotional factors: For a sustainable approach to be successful, it is important to have a clear idea about habits, lifestyles and preferences of a society so as to define applicable solutions and realistic responses to actual needs.

Continuity and replication: A sustainable approach should be a continuous and growing process to be able to fulfil all essential objectives; benefiting from previous success (UNEP, 2013).

CHAPTER

04

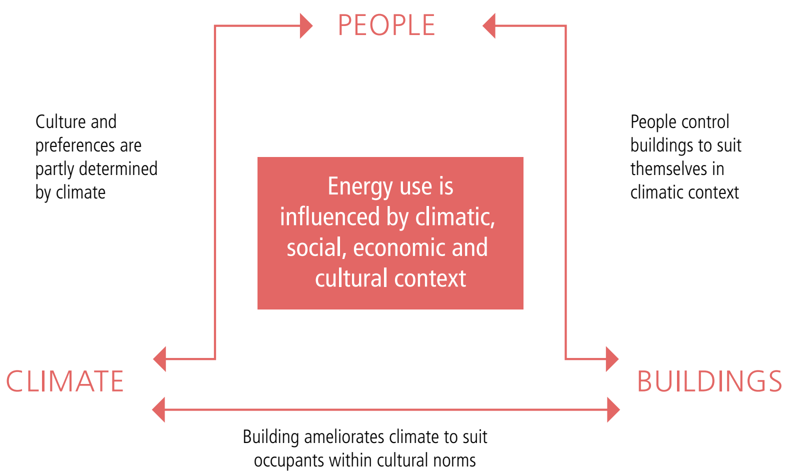
Strategies for greening social housing: new build and refurbishment

Green measures for new social housing

Design of green housing, to fulfil environmentally sustainable objectives, requires careful socio-technical consideration of site, building form, material selection, and technical services selection. Energy demand, for example, is a dynamic three-way interaction between climate, people and buildings (figure 4.1).

In an example mistake often made, positioning a house in the wrong orientation, can lead to inappropriate solar access, e.g. not enough solar access in the cold season and/or too much afternoon solar radiation in the hot season, can impact comfort, in turn leading to more space conditioning energy use through heating or cooling than would have been necessary. The following three sub-sections detail design principles that can be implemented to minimise energy use, to collect renewable energy and to sustainably manage water and waste.

FIGURE 4.1 DYNAMIC THREE-WAY INTERACTION BETWEEN CLIMATE, PEOPLE AND BUILDINGS DICTATES OUR ENERGY NEEDS IN BUILDINGS



Nicol et al., 2012

Bioclimatic (passive) building design principles

Passive, energy efficiency materials and methods are essential as first considerations for the construction of green social housing (UN-Habitat, 2012a). A significant portion of energy use in the conventional modern house is used to create a thermally comfortable, functional environment for the occupants. Houses that are passively designed take advantage of natural climate, material properties and the basic laws of physics to maintain thermal comfort. Passive design can be used to improve comfort by passively heating or cooling and providing daylight. This is the first and possibly most important step in reducing building energy use and carbon emissions for the in-use life of the building. Steps taken during passive design and implementation will lock the building into a life of efficiency or inefficiency. The fundamental principles of passive design can be applied differently to various climate zones, building types, construction methods and materials. Passive design is adaptable, has a low lifecycle cost and a long life.

Passive building principles are applied through design of the site configuration, building orientation, building configuration, and the materiality of the building envelope.

- **Site configuration and layout:** Closely tied with orientation and building configuration, placement of the building on or in the site can impact the operation of the building. Other elements such as trees and other buildings can provide shade when it is needed or adversely block the sun when it is needed. Placement of the building in the site, i.e., using the earth as thermal mass can be beneficial in regulating temperature swings throughout a day. This method is used in the New Generation of Yaodong Cave Dwellings case study, Section 5.2.6.

- **Building orientation:** The orientation of the building on the site must consider elements already on the site and the equator. For passive solar design the building must have the appropriate orientation of openings and spaces to achieve maximum light gain with minimal heat gain. Depending on the location in most cases, buildings benefit from predominately equator facing glazing or aperture oriented +/- 15 degrees from equator. Optimal orientation allows for simpler shading options. In addition, building orientation can take advantage of cooling breezes, seasonally avoid hot/cold winds, and also consider the impact of local geographic features (e.g. slopes, neighbouring buildings, trees etc.) on climatic conditions (e.g. prevailing winds). This method, along with thermal mass, is well demonstrated in the Passive Solar Housing in the Cold Desert of the Indian Himalayas case study, Section 5.2.10.
- **Building configuration and layout:** East and west facing facades should be minimised to reduce the exposure to the sun in the morning and evening; facades facing these orientations are difficult to shade. Depending on the location, housing clusters can be beneficial or detrimental for passive efficiency, e.g. in India, the Juanapur slum resettlement in New Delhi (figure 4.2) used a cluster design to provide shading and mass but allowed for the prevailing wind to flow through the cluster to provide cooling to the units (Anangpur Building Centre, 2013).

FIGURE 4.2 THE JUANAPUR SLUM RESETTLEMENT, NEW DELHI

Anangpur Building Centre, 2013

- Building envelope: The building envelope is a collective term for the roof, walls, windows, doors, and the ground floor. The envelope acts as a climate screen by controlling the heat gain in the hot season and heat loss in the cool season. Therefore, designing the thermal properties of the building envelop requires consideration or local seasonal temperature, humidity and rainfall variation. The design of the envelope can have a large impact on the amount of energy required to create a comfortable internal environment. The building envelope is augmented through the use of colours, insulation, thermal mass, and shading elements.
    - Lightly coloured exterior rendering on walls and light materials on the roof assist in reflecting solar radiation and minimise the conduction of solar gain into the house. *This method is often employed in new highly efficient dwellings such as Passivhaus designs because the higher efficiency of the homes retain any heat that is gained through the fabric for longer periods. This method can be seen in the Low energy and passive housing in Ljubljana case study, Section 5.2.3 and Lisnahull Terrace, Dungannon case study, Section 5.2.9.*
    - Green or soil roofs have historically been vernacular expressions in hot and cold climates for thermal insulation. As an example, sod has been a traditional way to keep buildings cool in Tanzania. Green roofs also assist in microclimatic cooling, reducing the urban heat island effect, rainwater runoff reduction and increase biodiversity. Green roofs generally have higher lifespans than conventional roofs due to the protective covering of the sod from the elements.
- Insulation is important for reducing the amount of heat flow into or out of a building. The required insulation levels in each element of the envelope for a home will vary depending on location.
- Thermal mass is currently sufficiently provided in housing where concrete and earth blocks are used and where a majority of flooring is compacted earth or compact earth with sand and cement screed on top. It may be best to continue these practices as long as the embodied energy and the cost of the methods can be minimised (UN-Habitat, 2012b).
- Shading of the building and outdoor spaces reduces summer temperatures by blocking direct solar radiation from being absorbed onto a particular surface and entering the building through conduction of the materials. Radiant heat from the sun passes through glass and is absorbed by building elements and furnishings, which then re-radiate it. Re-radiated heat has a different wavelength and cannot pass back out through the glass as easily. In most climates, 'trapping' radiant heat is desirable for winter heating but must be avoided in summer. Flexible shading can be used to permit or restrict entry of sunlight depending upon the thermal requirement. Shading reduces thermal discomfort due to solar gain and results in less or no need for mechanical cooling. Optimal seasonal shading can be provided through roof overhangs, trees, and window fixtures.

Low impact materials and construction techniques

There are a number of factors which classify building materials as sustainable. Before and during construction, materials are deemed environmentally sustainable when the embodied energy is lower than customary materials. Embodied energy is the total energy used to create a building product including all the processes involved in harvesting, production, transportation and construction. It can represent a significant proportion of the total energy used during the lifecycle of a home. Such measures as using local materials, minimal processing, reusing existing structures and materials and using renewable materials (which are quickly and easily replaced) are ways to ensure that embodied energy is low in a building.

Environmental sustainability is not simply a function of energy use in the life of a building but also considers the health of the occupants and those involved in the construction and deconstruction processes. Furthermore, to maximise the environmental benefit of the material the construction techniques must be used to achieve the passive design strategies outlined in Section 4.1.1.

Materials and methods for structure and envelope of the building

- **Rammed earth construction:** For the construction of walls, earth-based technologies offer ideal solutions for long-term sustainable construction programmes in dry climates. To create a rammed earth wall, formwork is assembled and layers of earth are compacted within the forms. Compacting of the earth is either manual or pneumatic and can easily be done through for community participation. Construction must be done in dry weather (Fielding et al., 2012).
- It is important to protect earth buildings from water (e.g. standing water and rainfall). To protect rammed earth and adobe buildings from water the following steps can be taken:
  - Chemical additive (e.g. mortar-proof) to inhibit water absorption in render – due to cost additive can be limited to external 'splash zones' of walls
  - Requires sufficient roof overhang and stone or concrete foundation to raise earth construction above ground
  - Damp-proof course should be considered to protect the earth wall from moisture rise
  - Stabilising agents (e.g. cement) can be used but have the drawback of increasing the embodied energy of the construction
- **Stabilised soil blocks and interlocking stabilised soil blocks:** There are many options when it comes to earth or soil blocks. The amount of stabiliser (content of cement), type of stabiliser, method of production, form of the blocks, and use of waterproofing agents can all vary in the production of soil blocks. It is possible to produce between 250-350 SSBs in a day using a simple block press. SSBs depending on method and content can be 70 per cent less energy intensive than fired bricks and 20-40 per cent less expensive. There is also the environmental savings with no fire wood use (Montgomery, 2002; Minke, 2006; UN-Habitat, 2012a).

Advantages	Disadvantages
Availability	Durability problems in wet conditions
Durability	Low flexibility for future change
Versatility/ easy workability	Maintenance
Low-cost/ affordability	Socio-cultural perception (poverty)
Community involvement level high	Structural limitations
Fire resistance	Water absorption
Excellent control of indoor moisture	Low resistance to abrasion and impacts
Low embodied energy/ environmental impact	Specialist skills needed for plastering
High thermal capacity	Slow construction process
Low thermal conductivity	Quality control important
Good sound insulation	
No/ low cement required	
Highly recyclable (depends on whether stabiliser is used)	

Source: *Hadjri et al., 2007; Fielding et al., 2012.*

Overall positive qualities are local material and production capability, flexible sizing, labour demand can create jobs, teaches brick laying skills, strong and stable construction method, long life, sufficient for earthquake zones, and rain and insect resistance. Interlocking blocks require no cement mortar and can be used in building easily with unskilled labour force. Typical SSBs require mortar but can be lime-based or consist of minimal cement. Non-interlocking blocks alternatively offer more flexibility in design. Finally, when load-bearing walls are constructed with SSBs and mortar reinforced concrete columns are rendered obsolete in low seismic risk areas, thereby reducing the embodied energy of the overall construction project. Disadvantages are that SSBs cannot be used to construct high rise buildings, in wet conditions or underwater, and initial first cost of block press (Fielding et al., 2012; UN-Habitat, 2012a).

Mechanised production such as with Hydraform produces blocks quickly and operation takes only one to two days for training. This method is useful for large scale projects and has been performed in a large number of African countries. Drawbacks of mechanised production include high initial capital input and machinery fuel requirements. A small level of training is also required (Fielding et al., 2012).

- **Straw-bale construction:** Straw is a renewable resource that is readily available in many parts of the world. Straw bales are an inexpensive alternative to other building materials and can be used to build homes in the way bricks are used (Tessema et al., 2009). The straw bale can be used as a structural construction material, a thermal insulator (very good insulative abilities, reduces thermal bridging) or for acoustic absorption. Straw bales can be used as an infill in a wooden structure or load bearing without any skeletal structure. If used as bricks they need to be pre-compressed before plastering to avoid later compression by the roof. Straw bales can be tied together and plastered after trimming. Load bearing straw-bale walls can be built up to three stories; infill straw bale walls have no limitation of height as long as they are adequately braced.

  Straw bale construction provides the most cost effective thermal insulation and sound insulation available. Straw bales are tightly packed and covered with a skin of cement render providing dense walls with a nearly airless environment creating a highly fire resistant construction. Conclusive evidence of its fire resisting performance can be found in laboratory fire tests conducted at the Richmond Field Station in 1997 by students at University of California Berkeley. These rated a straw-bale wall at two hours. Straw bale homes also survived Californian bush fires that destroyed conventional structures.

  Straw-bales are easy to use without highly developed skills or machinery. However, bales of straw should be uniform in size being approximately twice as long as wide; and as densely compacted as possible with tight strings/wire/twine at the maximum compression strength of a baling machine if possible. Bales should be laid on edges and not flat for better R-value. The moisture content of the straw bales should be kept under 15 per cent with the help of an adequate foundation, long roof overhangs, directing guttering away from the walls, by choosing appropriate rendering materials, and using high foundations (DCCEE, 2011). Straw bale wall construction can be made water proof or resistant with parge coat or Grancrete (sprayable concrete mix) (UN-Habitat, 2008).

  Limitations:

  - The design of other building elements should be made according to the dimension of the bales.
  - The bales should be kept dry during the whole building process and load bearing straw-bale construction suits drier climates.
  - Straw-bales need to be made before using them in the construction; they need to be uniform in size and cannot be adjusted afterwards.
  - Most buildings require a frame of timber or steel to comply with many building codes (DCCEE, 2011).

- **Cob construction:** Cob is a form of unfired clay brick. Cob combines straw and earth which makes it an optimal material for hot and dry climate as it has good insulative characteristics (straw) and a thermal mass (earth). It can be used in wet climate if covered with roof overhangs, protected with plaster and raised from the ground with an adequate foundation (DCCEE, 2011).

For extra insulation, increase the amount of straw or substitute perlite, vermiculite, or pumice for sand. Pumice cob is difficult to mix and hazardous to the skin because of all the tiny, glassy fragments. Sawdust or wood chips can also be used to increase insulation but reduce strength and slow the drying. Alternatively, for extra hardness or thermal mass, increase the amount of sand, and reduce the proportion of straw. To improve thermal performance, build exterior walls with an inner layer of high-density, sandy cob with better-insulating, straw-rich cob on the outside of the wall (Evans, et al., 2002).

Cob has good loadbearing ability; is inexpensive; availability on site; need for very few tools and no form work; creates strong and durable walls; fire proof; and flexible. Cob is a low-impact, energy efficient building material that can create interiors that are warm in winter and cool in summer (thermal mass). It is strong in compression, very durable and it can be moulded to different shapes. Some skill is required as with any soil construction method, there should be earth quality control of strength and the connections between ingredients in the mix before using soil in cob construction (DCCEE, 2011).

A manual cob mixing method has been developed using a tarp (or square piece of durable, slick, and water-resistant material) as opposed to mixing with shovels on a level platform made of tamped earth, concrete, or plywood. The tarp method is quicker, easier on the lower back, and requires fewer tools. The work can be done mostly on an individual basis. The most efficient way for a group of people to mix cob is for each person to have their own mix on their own tarp. They can pair up for the initial stages of mixing by rocking the tarp back and forth between them, then complete the stomping, rolling, and straw-adding stages on their own (Evans, et al., 2002).

Limitations:

- Construction is usually time consuming and labour intensive.
- Walls should be protected from rain during the construction with a temporary roof. It takes 6-9 months for thick walls to dry completely and they will shrink in the process. After this doors and windows can be added (DCCEE, 2011).
- As with other earth construction methods there may be a social stigma that will need to be resolved.

- **Insulation materials:** Agricultural waste or production such as straw and sheep's wool can be used as insulation to increase the thermal resistance of the envelope of a building. Other natural materials used for insulation include: flax, cotton (including recycled clothing), wood and hemp fibres (UN-Habitat, 2008).
- **Cement replacements for concrete:** Portland cement, generally used to make concrete is highly energy intensive to produce. There are alternatives which can be sourced locally depending on location. As an example, rice husk ash has been used in pilot projects in Columbia, Thailand and India. Magnesium oxide and magnesium chloride cements require only 20-40 per cent of the energy required to produce Portland cement and is more readily recyclable (UN-Habitat, 2008).

- **Nubian Vaults (Voute Nubienne):** Nubian vaults are earth roofs which do not require framing due to the vaulted structure and provide thermally massive environments (regulating the internal temperature). The method has been perfected in some sub-Saharan countries, e.g. Burkina Faso, Mali, Senegal and Togo and is able to withstand short heavy rainy seasons by using plastic waterproof sheeting to repel penetrating rainwater (Tessema et al., 2009). Like other earth building methods, though culturally relevant, the Nubian vaults may find opposition in being associated with poverty and under development and even may find difficulty being acceptable for planning permission in some towns and cities (Hadjri et al., 2007). The extent of the rainy season in particular areas may also be a cause for concern with the construction method.
- **Eco-shake roofing materials:** A replacement for common wood shingles, eco-shake is 100% recycled material, reinforced vinyl and cellulose fibre. The eco-shake outperforms wood in extreme weather conditions, is suitable for all climates, is UV protected, lightweight and is wind, fire and impact resistant (UN-Habitat, 2008).
- **Windows:** Windows must be operable for ventilation. All openings need to be shaded from summer sunlight with roof overhang, shutters, awning, etc. Houses in some areas require security bars on windows and insect screens. Glass for windows can often require import, however; materials from the construction industry can often be reused (and recycled), including exterior glass (UN-Habitat, 2012a; UN-Habitat, 2012c)

Low energy building services

- **Improved efficiency cooking stoves:** Inefficient stoves can cause indoor air pollution which is harmful to the health of the occupants. Aside from reducing or eliminating the indoor pollution, high efficiency cooking stoves reduce the amount of wood needed for cooking and heating therein reducing deforestation, leading to decreased soil erosion, and water resource protection A case study in Nigeria is outlined in UN-Habitat (2012a): Nigerian stove replacement programme lead by Nigerian Developmental Association for Renewable Energies and German NGOs, Atmosfair gGmbH and Lernen-Helfen-Leben. The benefits of this programme were that the new stoves saved up to 80% fuel wood and in so doing, reduced deforestation. Indoor cooking, particularly with inefficient equipment can also lead to high internal heat gain in hot climates contributing to thermal discomfort during the warmer seasons. To reduce summertime heat in houses a design alternative can be to create outdoor cooking areas so that the heat may escape to the atmosphere rather than being trapped in the house.
- **Energy efficient light bulbs:** An energy efficiency programme in India called Bachat Lamp Yojana (Lamp Savings Project) is led by private-sector companies to provide compact fluorescent lights (CFL) to households at the price of incandescent bulbs. The difference in cost is recovered through the carbon credits accrued from lower energy use; managed and supported by the electricity distribution companies (ABPS Infrastructure Private Limited, 2009).

- All effort should be made to maximise the efficiency of lighting. It is highly recommended that light emitting diodes (LEDs) are used over CFLs and incandescent bulbs. LEDs are the most efficient and long lasting. Though CFLs are significantly more efficient than incandescent bulbs, CFLs contain mercury, must be disposed of properly and care must be taken to not break CFL bulbs. All elements of a CFL bulb can be recycled; it is highly recommended that the arrangement for recycling of CFLs is in place. Depending on electricity sources, CFLs actually reduce the amount of mercury released to the environment. Coal burning power plants are responsible for about half of the mercury released into the environment from man-made sources (USEPA, 2013).
- **Cooling:** Builders are able to create cooler environments in homes by following passive cooling measures outlined previously, particularly shading from incident solar radiation and using highly reflective surfaces on walls and roofs. It is essential that passive measures are implemented to the fullest before more complicated means of cooling are explored. Thermal mass in the homes will also help relieve the heat of the day. Some discomfort could be experienced in locations where heat and humidity are not easily tackled with shading. However as described in Section 2, since the core concept of "thermal comfort" is more of a state of mind (reflecting different cultural, class and geographical conditions) than a technical certainty, the adoption of western benchmarks for comfort (achieved by active cooling technology) should be vigorously discouraged. Improving awareness about good behavioural practices and natural ability to adapt to a range of temperatures can impact the way future generations use energy. Air-conditioning should be avoided for developments to remain sustainable and to avoid applying strain on the electrical supply.

The following are options for reducing thermal discomfort in hot conditions:

- **Thermal Chimney:** Via convection, thermal chimneys allow cooler air in to the house while pushing warmer air out. Thermal chimneys can be made of a black, hollow thermally massive chimney like form with an opening at the top for hot air to exhaust. Increasing the temperature at the top with direct sunlight increases the up-draught. Inlet openings are smaller than exhaust outlets and are placed at low to medium height in a room. When the hot air of the interior rises, it escapes through the exterior exhaust outlet. As this happens, an updraft pulls cool air in through the inlets. Ideally for maximum airflow, interior doors are also left open. Earth pipes can also be used to benefit from removing heat through the chimney effect (Trimarchi, M, 2013).
- **Fans:** Fans are inexpensive to run and have the least greenhouse impact, while air conditioners are expensive to run and produce more greenhouse gas. Fans are overall inexpensive options for relief of thermal discomfort. They circulate air but do not reduce temperature or humidity.
- Solar thermal cooling technology is a technological alternative to conventional air-conditioning. Solar thermal cooling uses solar thermal systems integrated with air conditioners or heat pumps to provided mechanical cooling.

The technology is however expensive and requires a high level of expertise.

- **Heat pumps** (see below)

- **Heating:** The necessity for heating in many locations can and should be minimised through the use of passive measures, e.g. solar gain, thermal mass and insulation. If thermal efficiency of the building envelope and thermal mass are efficiently integrated and maximised this may reduce or eliminate thermal discomfort. The following option is an alternative to standard boilers or electric heating.
  - Ground / water source heat pump: Heat pumps use existing heat sources to offset the temperature at which the heat conveyor, e.g. water, must be heated. Heat pumps can also be reversed for cooling purposes. In the example of a ground source heat pump (GSHP) the underground temperature can be used to offset the heating or cooling demand. Heat pumps use electricity but far less than conventional electrical heating methods. Heat pumps require a high level of expertise and may require local technicians for maintenance and upgrades throughout the life of the system. The most efficient use of the heat in a heat pump system is through radiation heating in the home, e.g., wall radiators, under floor heating. Air source heat pumps are also available but can be slightly less efficient.

Integration of renewable systems

- **Solar water heating systems:** Solar water heating systems use energy from the sun to heat water at no in-use costs. The upfront cost, however, of solar water heater (including installation) is higher than conventional systems. There are two types of solar water heating collectors, flat plate collectors and evacuated tube collectors. In constantly sunny climates flat plate collectors are more efficient whereas in more cloudy conditions their energy output drops off rapidly in comparison with evacuated tube collectors (GreenSpec, 2013).

- **Photovoltaic panels:** PV systems can be designed for a variety of applications and operational requirements, and can be used for either centralised or distributed power generation. PV systems have no moving parts, are modular, easily expandable and even transportable in some cases. Energy independence and environmental compatibility are two attractive features of PV systems. In general, PV systems that are well designed and properly installed require minimal maintenance and have long service lifetimes.
  - **Grid Connected** – The solar system is connected to the local electricity network allowing any excess solar electricity produced to be sold to the utility. Electricity is taken back from the network outside daylight hours. An inverter is used to convert the DC power produced by the solar system to AC power needed to run normal electrical equipment. For this arrangement to be successful there would need to be compensation (feed-in tariff) for the energy fed into the grid for the homeowner from the utility company. The feed-in tariff is an effective way to encourage uptake of these systems and to stimulate local industrial development and sales of PV technology.

- Off-grid - Completely independent of the grid, the solar system is directly connected to a battery which stores the electricity generated and acts as the main power supply. An inverter can be used to provide AC power, enabling the use of normal appliances without mains electricity (GreenSpec, 2013).

There are two main types of PV technology, these are thin film (amorphous) and crystalline (mono or poly). Thin film cells are the least efficient but have the advantage of easier installation and assembly, low cost of substrates or building materials, ease of production and suitability to large applications over crystalline panels. Though the efficiency of thin film modules is lower than that of crystalline modules, the modules are typically priced accordingly. Thin film modules have various (often flexible) coating and mounting systems. Some are less susceptible to damage from hail and other impacts than those covered in glass (DCCEE, 2011).

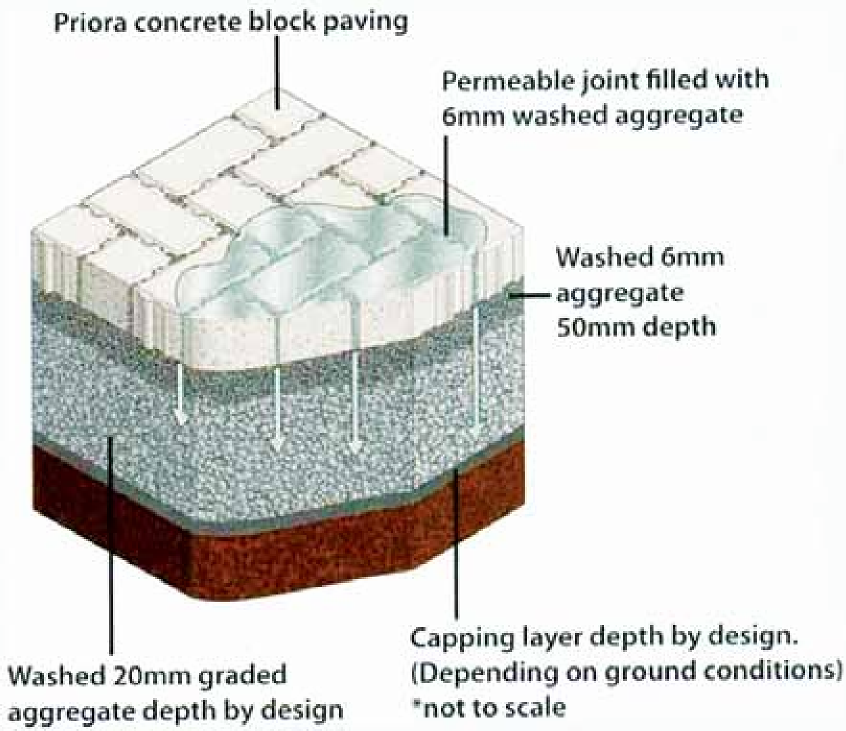
Limitations: like the solar hot water system, PV systems have high upfront costs and require a high level of expertise to install and manage. Both systems also require a large selection of imported materials (e.g. glass, mounting frames, and cells). Shading is critical. Minor shading can result in significant loss of energy. This is because the cell with the lowest illumination determines the operating current of the series string in which it is connected. These effects must still be considered, preferably in the first stages of building design. Dust and soiling may also cause a power reduction (GreenSpec, 2013).

Drainage, water supply and sanitation

Serious existing problems as a result of rapid urbanisation will need to be addressed and resolved in new housing. These issues include solid waste management, sufficient storm water drainage, water supply, sanitation, and in some locations mosquito control (UN-Habitat and UNEP, 2009).

All paved or non-paved areas should be sloped (7mm recommended) away from the house. This ensures that the water does not flow into the house or pool around and saturate the ground around the foundation. Drain tiles around foundations provide further assurance that water does not saturate the ground around the foundation. These drainage conduits need to lead water away from the home and guide it toward designated storm water management areas. Storm water needs to be guided and given a place to go. Storm water management areas such as retention ponds protect developments and surrounding areas from flooding. Retention areas are recommended over storm water detention (only dry out under drought conditions) areas. Retention areas are designed to hold storm water until water naturally leaves via percolation and evapotranspiration. Water in retention area must dissipate within 72 hours so that more water can be accommodated. It is easier to achieve mosquito abatement in retention areas as opposed to detention areas (O'Meara, 2011). The following building sustainable practices, sustainable urban drainage systems, rainwater harvesting and green roofs, will assist in reducing the storm water runoff that must be managed in retention areas.

FIGURE 4.3 PERMEABLE PAVING



Crystal Clear, 2013

Sustainable urban drainage systems

Sustainable (urban) drainage systems or SUDS is an alternative to hard impermeable paving with the capacity to decrease the amount and velocity of surface runoff, reducing the storm water quantity that can lead to flooding, pooling, or the water that enters retention areas or sewage (GreenSpec, 2013).

The avoidance of flooding or pooling of water reduces the risk of mosquito breeding and damage caused by water ingress into the home. Reducing or disallowing rainwater from passing over hard impermeable surfaces reduces the amount of pollutants that are picked up by the water. SUDS can either be in the form of permeable paving stones (figure 4.3) or structural sod. Lightly coloured paving stones or green cover can also help reduce the urban heat island effect.

Rainwater harvesting

Rainwater harvesting is another method used to reduce or eliminate water runoff from a building. Depending on size, rainwater harvesting systems can offset water restriction during times of drought. Rainwater harvesting vessels can range from simple water butts for garden watering to large underground tanks for development or neighbourhood scale use. The collected water can be used to water gardens or serve indoor uses such as for WCs and washing machines. Storage tanks above or below ground are made from plastics, glass reinforced plastics or concrete. Underground storage tanks have higher installation costs but reduce above ground space lost and can last twice as long (specifically the plastics). External pumps for larger systems (not located within the tank) are recommended as they are easier to service and can last longer than those located within the tank. Rainwater harvesting or recycling systems can be dependent on periodic inspection, cleaning, servicing and component replacement. These limitations can also incur costs however; much can be done independently (GreenSpec, 2013).

The Tlholego Ecovillage in South Africa has demonstrated the ability to catch water for drinking, irrigation and other household uses. The first level of catchment takes place on the rooftop through a gutter system which flows into a storage tank for drinking water and irrigation. During the rainy season, greater quantities of water is captured and stored underground in tanks. This water is also used for irrigation during the dry season. Greywater is also collected from bathrooms and kitchens for irrigation. The ecovillage also uses composting toilets for fertiliser (Tessema et al., 2009).

Grey water recycling

A grey water recycling system recycles bath and shower water for toilet flushing. Grey water recycling can reduce water use by a third (depending on water use habits) and most importantly minimises the amount of potable water in the wastewater system (GreenSpec, 2013).

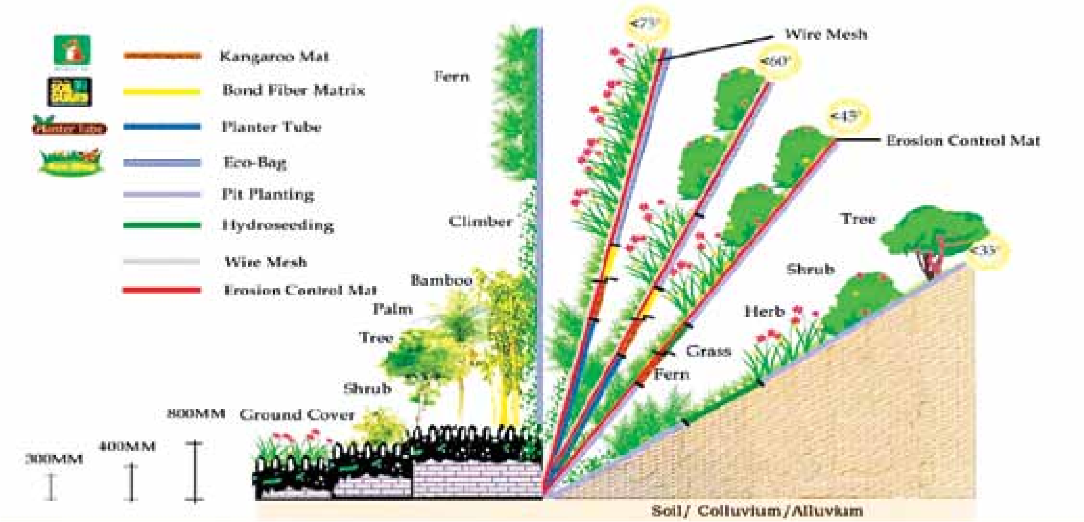
Composting toilets

A composting toilet is a self-contained unit that treats waste using aerobic decomposition (composting). A composting toilet completely removes a significant amount of potable water waste from the home. Some carbon based material or bulking agent, such as dry leaves or softwood shavings, should be regularly added to the container, preferably daily or with each use. This provides the proper carbon-nitrogen mix, helps aerate the pile and prevents compacting. A composting toilet that is working well does not smell. Offensive odours usually indicate that something is wrong. Often adding bulking agent in greater quantities or more regularly will remove the smell. Regular care is required. The output compost is usable for fruit trees and bushes around the garden (DCCEE, 2011; GreenSpec, 2013).

Green roofs

Green or soil roofs have been vernacular expressions in hot and cold climates for thermal insulation. As an example, sod has been a traditional way to keep buildings cool in Tanzania. Green roofs also assist in microclimatic cooling, reducing the urban heat island effect, rainwater runoff reduction and increase biodiversity. Green roofs generally have higher lifespans than conventional roofs due to the protective covering of the sod from the elements.

FIGURE 4.4 VARIATION IN VEGETATION DEPENDING ON SOIL SLOPE



Toyo Greenland, 2009

Figure 4.4 shows that greenery can be used to cover all slopes from roofs to walls. Green roofs require adequate structural support and would require a moderate level of expertise to ensure a long lasting roof. There are generally two types of green roofs:

- **Extensive** – Extensive has a build-up height of 50-150mm, light weight and easy to install. Extensive roofs require no irrigation and are low maintenance. Planting is generally moss, sedum, herbs and grasses.
- **Intensive** - Intensive roofs have a build-up height of 150mm-1500mm. These roofs require substantial structural support, irrigation, maintenance. Uses include natural gardens, growing food, and recreational space. Intensive roofs are generally flat (GreenSpec, 2013).

Construction of a green roof: the roof structure is covered with a membrane surface that is covered with water proof insulation, which are then covered with plastic sheeting (root barrier). To build up the substrate, pea gravel (drainage layer that directs water from the roof), a filter fabric keeping material from the drainage layer and an optional water retention fabric on which the mulch and soil base and vegetation layer is placed (UN-Habitat, 2012a).

EcoHouse retrofit case study in Rio de Janeiro, Brazil

A case study EcoHouse in Rio aimed to create an environmentally friendly house as an example for other modest EcoHouses in hot and humid climates. The house's many characteristics featured rainwater harvesting, passive cooling and a green roof.

- **Rainwater harvesting:** rain water is collected from the roof and patio, is filtered and then pumped to a cistern on the green roof. The water is then distributed by gravity to toilets and the garden irrigation system. In the first year of use the system accounted for 28 per cent of the total water use in the house.
- **Passive cooling:** Though the orientation was already established (being a retrofit), the strategic placement of trees, the extension of eaves and the shading of windows were all done to avoid direct sunlight and to help the house remain cool. The interior of the home was also reconfigured to maximise natural ventilation.
- **Green roof:** the green roof is used to absorb the direct sunlight that would otherwise heat the roof and the interior.
- **Renewable energy:** two solar thermal systems heat the hot water use for the house (Rich, 2006).

Environmental retrofitting of social housing

Retrofitting existing buildings can result in significant reduction in emissions from (reduced) material production and transport and construction waste. In developed countries like the UK and much of Europe, a majority of building standing today will still be in use long into the future. In order to meet respective GHG emissions reduction requirements, retrofitting the existing stock is essential. Section 5 presents some case studies in green retrofitting for social housing purposes.

Most environmental retrofits are concerned with (as further detailed in Section 4.1):

- **Building fabric upgrade:** to reduce energy consumption (and resultant costs and emissions) and increase thermal comfort and health of the occupants, and;
- Advanced service and system installation to reduce energy and/or water consumption through active technological means

The following points are important considerations for a successful retrofit project (TSB, 2013):

- **Project planning:** Time spent in detailed pre-design; careful sequencing of works, enabled by well-coordinated procurement
- **Site management:** Dedicated co-ordination of the retrofit project; open and frequent communication between project team members; understanding among all site workers of importance of high performance/ energy efficiency, etc.
- **Understanding the supply chain:** Anticipating the availability, price and lead times of innovative products; working with the suppliers of control systems to ensure that those installed are fit-for-purpose and simple to understand
- **Working closely with residents:** Engaging residents early and frequently in the process; helping residents to understand how to manage their homes at different times of the year by explaining system controls

Maintenance and management approaches

Traditional affordable housing projects tend to require more maintenance than market-rate housing however, green buildings can be built to be more durable and require less maintenance. The use of more durable materials and components is a technique inherent in green building that saves materials (and costs) through avoided maintenance and replacement. Additional up-front investment in a more durable design can lead to cost savings through the life of the building, and should be quantified as best as possible (Bradshaw et al., 2005).

Durability in materials: Greater attention to building component durability reduces maintenance frequency and costs (Bradshaw et al., 2005). Alternatively where local and renewable materials are used and where the occupants are well trained in the use of the materials, maintenance can be easy to deal with from an occupant point of view. For lighting, CFLs or LEDs reduce maintenance costs due to longer bulb life.

The xeriscape approach to landscaping is a theoretically maintenance free approach to outdoor space and green roof vegetation. This technique uses native plants to reflect local character and cut down on external water use needed to keep plants alive. By using only local species, only plants that grow in the climate naturally are used, meaning that they will require less maintenance and water than other species (Bradshaw et al., 2005).

Flexibility in Design: Design built to enable flexible expansion or reuse of the building ensures the sustainability of the development beyond the initial purpose. A significant benefit of a building that is able to be reused is the prevention of the destruction and disposal of the materials. The versatility of the house to meet the needs of the occupant throughout their life (accommodation for future disability or growth in family size) also helps to prevent disposal or excessive reconfiguration.

In developing countries, incremental housing where the basic necessities (kitchen, WC and shower, living / sleeping quarters and services) are initially provided free of cost with provision for future structured expansion by the occupants has been found to help create a rich sustainable habitat. The design of the build should accommodate the possibility of future expansion by minimising the extent of demolition and material waste. The use of materials that are recyclable can also assist in the reconfiguration of the building or the total reuse of the materials for future use.

Monitoring and evaluation of green social housing

Monitoring and evaluation of sustainable housing practices is vital for demonstrating to various actors, including the political institutions and the national/ international financial institutions, the benefits of sustainable housing. In many cases there can also be a performance gap between design intent and actual performance of green buildings (or any building). All stakeholders can be responsible for addressing this gap by initially working together, communicating effectively and evaluating the performance of the built product. In doing so, the performance gap can be quantified and future changes can be made to avoid common mistakes.

Monitoring and evaluation should feed into policies and help secure funding. It is important to monitor and evaluate all aspects of sustainable housing including social, economic and cultural (UN-Habitat, 2012a). Furthermore, the evaluation methodology can ensure progressive development of green building ideas, design decisions, material use, systems installation and commissioning through the essential step of documentation and forward-feeding of lessons learned. To do this effectively it is essential that all teams involved document, learn from and feed-forward results for future design and construction decisions. A national or local green building group would be invaluable in spreading and enabling the learning from this process.

Impact evaluation can take many forms in terms of complexity and extent of evaluation. As noted above there can environmental, social, economic and cultural evaluation. This section will focus specifically on the environmental impact assessment of buildings. The evaluation of impact and performance is important for a number of reasons:

- New or improved building material, systems and methods need to be evaluated for success or failure and future improvement
- Evaluation can show where faults exist which can be improved in the existing building
- The performance gap (the difference between predicted performance and actual performance) can be quantified and suggestions for improvement can be defined for both the prediction process and the building process
- The complicated dynamic and communication process between, clients, finance group, designers, builders, suppliers, etc. can be evaluated for faults and future improvement
- Impact evaluation forces the stakeholders in the building process to be involved in the occupants understanding and appropriate operation of the building
- With regard to environmental impact and performance, evaluation processes provide the capacity to quantify such variables as water use, indoor air quality, in-use carbon dioxide emissions, embodied energy of materials, thermal comfort, energy generation and demand.

In developed countries tools such as LEED and BREEAM are used to assess some impact evaluation. These tools are not always easily directly implemented in developing countries. Intermediate tools need to be introduced; depending on the intent, tools with greater focus on monitoring and performance evaluation exist and can be used. One of the possible tools to be used is Sustainable Building Assessment Methodology (SBAM) developed by SKAT (Swiss Resource Centre and Consultancies for Development). SBAM is a participatory tool conducted through a workshop where stakeholders (30-35 participants including community members, private sector, public sector, donors, authorities and professionals) define context-specific qualitative and quantitative indicators for sustainable building practices based on experiences and needs of the specific community; assess already implemented building projects; and select solutions (such as sustainable technologies) for future interventions. Environmental, social, institutional, economic and cultural dimensions are considered and the life cycle of the building process looked into. A web based software application is used to organise, present and store the information gathered (UN-Habitat, 2012a). These tools, specifically, LEED and BREEAM, predict impact with a small level of post-construction evaluation. Other methodologies and tools like building performance evaluation and Soft Landings focus entirely on the impact and evaluation of the built product, sometimes following the building a few years after construction ensuring maximum benefit and performance.

Building performance evaluation

The main purpose of building performance evaluation (BPE) is to maximise the intended efficiencies (minimising unintended issues) through closing the performance gap and contributing to future closure through the learning process (minimising future unintended consequences). The key benefits of BPE can be categorised into time-frames, short, medium and long-term benefits:

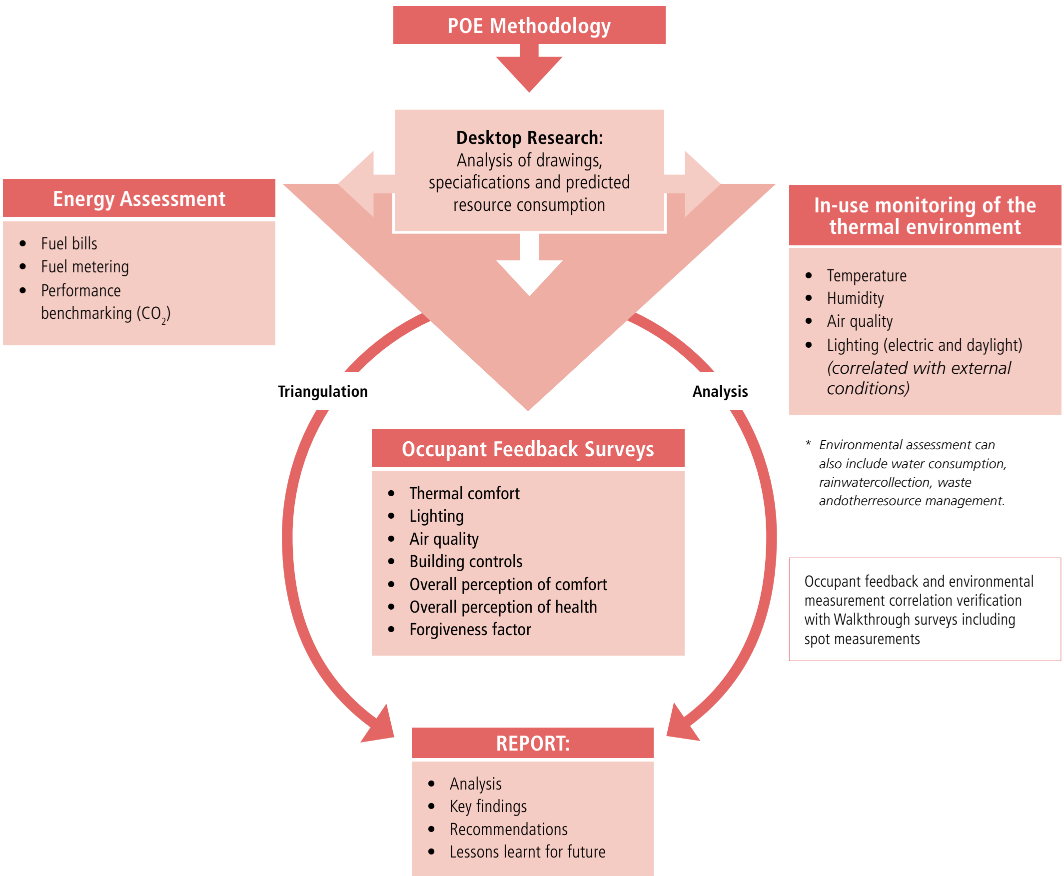
- **Short-term benefits** - immediate design decisions and facility maintenance and management issues resolved
- **Medium-term benefits** – lessons learnt fed-forward to future projects for all teams involved i.e., architect, construction, consultants, building owners, etc. Closing the feedback loop.
- **Long-term benefits** - improving the long-term performance of buildings and to justifying financial investment and major expenditures through monitoring and verification.

BPE is a methodology that can be divided into two separate phases. These phases are 1) post-completion and handover and 2) In-use.

- **The post-completion and handover phase** can be divided into three stages. These stages cover the following: 1) Design and construction audit – predicted performance calculations review, drawings and specifications review, interviews and walkthroughs with design team, client and developer (different sessions), observation and review of systems controls, and photographic survey; 2) Post-construction audit – fabric testing using various methods such as co-heating test, air permeability test, thermographic imaging, and U-value measurements, review of systems performance and commissioning; 3) Handover and early occupation – observation of the handover to the occupants, review of home user guidance, questionnaire surveys of acceptability, thermal comfort, initial reactions, and walkthrough interviews with occupants.
- **The in-use phase** involves a qualitative and quantitative assessment. The qualitative involves the on-going assessment of the user's experience and opinion through seasonal interviews and questionnaires. User assessment can also include diaries. The quantitative assessment of energy use, water use, indoor air quality, etc. is done through collection of energy and services statements and monitoring of variables such as temperature and indoor CO_2 concentrations. The qualitative and quantitative elements are compared for analysis.

BPE, in-use phase has three main areas of study, energy use, environmental conditions, and occupant feedback. These three areas of study when taken alone to analyse and report on the post-occupancy performance of a building is known also as post-occupancy evaluation (POE).

FIGURE 4.5 THE THREE ELEMENTS OF IN-USE BPE / POE



adapted from: Gupta and Gregg, 2014.

Energy and environmental performance

Evaluation of energy and environmental performance is an important element of the in-use stage of evaluation. The following table lists tools (not exhaustive) that can be used to evaluate the in-use energy and environmental performance of retrofitted or new-build homes.

TABLE 4.1 COMMON RETROFIT BPE TOOLS AND ACTIONS TO ASSESS ENERGY AND ENVIRONMENTAL PERFORMANCE

Tool/action	Stage	Measures	Reveals/provides
Metering of energy consumption or generation and water consumption	Pre-retrofit BPE (ideally before design stage) In-use (post-retrofit) on-going	Energy use of whole or individual equipment/ appliances (individual power meters can be used for appliances)	Baseline for post-retrofit comparison **energy use:** isolation of performance and problem solving
Environmental spot measurements, on-going onsite monitoring and climatic data collection (weather station)	Pre-retrofit BPE (ideally before design stage) In-use (post-retrofit) spot measurements – seasonally or annually/ monitoring on-going	**Internal:** temperature, relative humidity (RH), CO_2 (proxy for indoor air quality (IAQ)), daylight factor, and noise levels **Advanced IAQ:** ventilation flow rate, VOCs, NO_x, CO, etc. **External:** temperature, RH, and solar irradiance	Pre/ post-retrofit comparisons, comparisons with occupant perception, and isolation of irregularities with implications on energy use
Infrared thermography (effective in combination with air permeability test and assist in locating ideal locations for smoke tests and U-Value measurements)	Pre-retrofit BPE (ideally before design stage) Post-completion (fabric testing) Construction completion evaluation	Qualitative visualisation of surface temperatures	Heat loss, thermal bridging, gaps in insulation, changes in insulation, areas of in/ exfiltration, etc. Identify areas in need of improvement or repair

Cohen et al., 2001; IfS, 2011; Gupta et al., 2013.

Feedback on resident expectations and satisfaction

As with energy and environmental monitoring, collection of feedback on resident expectations and satisfaction is an important element of the in-use stage of evaluation which can be cross-examined with the former. Feedback evaluation can include:

- Walkthrough evaluation of all elements from systems, to controls, to occupant behaviour. The walkthrough allows the occupant to guide the evaluator through the home and to present the home through the eyes of the occupant. Allowing the occupant to lead can quickly point out what is well understood and what is not well understood by the occupant. Furthermore, the occupant will likely present issues.

- Second, questionnaire surveys and interviews are used to assess occupant satisfaction and behaviour. Beyond questions regarding thermal comfort, lighting, ventilation, air quality and noise there are questions looking for the user's perception and satisfaction in general. For example, does the house satisfy the occupant's needs? In addition:
  - Building controls: Assessing the occupant's indoor environmental satisfaction (covering thermal comfort, air quality, ventilation and daylight), their current levels of environmental awareness, and use of controls, comparing it with monitored data and post-completion control interface review (where applicable).
  - Building design and aesthetics: Testing preliminary environmental strategies of the building (orientation, services, etc.) and evaluating success or otherwise from the perspective of the different users of the building (Gupta and Gregg, 2014).

TABLE 4.2 COMMON RETROFIT BPE TOOLS AND ACTIONS FOR OCCUPANT FEEDBACK

Tool/action	Stage	Measures	Reveals/provides
Questionnaire, interviews and walkthroughs for occupants	Pre-retrofit BPE (ideally before design stage) In-use (post-retrofit) seasonally or annually	Occupant satisfaction, habits, and concerns	Opinion on aesthetic, comfort, noise, air quality, perception of health and control, etc. Pinpoint issues, problem resolution
Occupant participation tools, e.g. journaling, photographic and video audits (by occupant) and focus groups	Pre-retrofit BPE (ideally before design stage) In-use (post-retrofit) seasonally or annually	Occupant satisfaction, habits, and concerns	Occupant habits, opinion, and interaction Pinpoint issues, problem resolution

Cohen et al., 2001; IfS, 2011; Gupta et al., 2013.

Summary

Building orientation, form and envelope (colour, thermal mass, and shading) contribute towards creating a locally appropriate 'passive design' which utilises natural climate, material properties and physical laws to maintain internal thermal comfort. Solar passive design considerations (appropriate and well-distributed access to sunlight and wind), need to be an essential aspect of both site and building level planning/design. Other important aspects are flexibility for adaptation and expansion; incorporating local culture and vernacular architecture; local participation in design and construction.

Sustainable building materials have a minimal impact on the environment, occupant health and use less energy than conventional materials over the entire lifecycle of the product (harvesting, production, transportation, construction, maintenance, demolition, recycling). Some basic considerations when choosing sustainable materials are local availability, durability, workability, structural capacity, embodied energy, thermal performance, affordability, disaster risk (fire, flood, and earthquakes), impact on indoor air quality and health, recyclability, installation and maintenance requirements.

Building services equipment can have more environmental impact in production but can save significantly over the life of the building. Building services include provision for plumbing, sanitation, drainage; fuel for lighting, appliances, cooking; energy generation; heating and cooling systems where necessary. Efficient cooking stoves, energy efficient lighting, solar thermal heating and cooling, renewable technologies like photovoltaic panels can contribute to the minimisation of the buildings impact on the environment as the building is used.

Evaluation of the construction process and building performance is essential to help shape future policies and practices; create evidence base for promoting green buildings and to help secure funding for exemplar projects. Impact evaluation can have varying complexities and focus on environmental, social, economic and cultural aspects, however the three key evaluation criteria recommended initially are – energy use, comfort and occupant feedback.

CHAPTER

05

Case studies of green social housing

This section presents case studies in green social housing. Sub-section 5.1 (table 5.1) presents the framework used to identify and assess the sustainability of social housing projects with green innovations using the various criteria identified. There are projects which are able to demonstrate implementation of multiple criteria. Equally not all case studies satisfy all criteria. Sub-section 5.2 outlines the 10 best practice case studies which are subject to the framework in table 5.1 and sub-section 5.3 presents these case studies in detail.

The framework includes different criteria relating to policy instruments, financial models for delivery, cost of development, cost to occupants and details of sustainable and technical measures implemented. Developed and developing countries were both considered to assess the range of general lessons which can be applied for implementation of green social housing (sub-section 5.4). Finally sub-section 5.5 presents four green social housing case studies in the UK which failed to meet their particular goals resulting in greater than projected energy consumption (and carbon emissions), not meeting regulatory design guidelines, and occupant dissatisfaction relating to overly complicated systems and thermal discomfort.

Matrix for case study selection

TABLE 5.1 MATRIX FOR CASE STUDY SELECTION

CRITERIA	CASE STUDY 1	CASE STUDY 2	CASE STUDY 3	CASE STUDY 4	CASE STUDY 5
	Building Restoration for Social Housing Purposes: Celso Garcia, 787	Sustainable Village: Post-earthquake reconstruction and rehab. in Da Ping	Low energy and passive housing in Ljubljana	Technical team planning for self-help housing in the Kambi Moto Community	Cato Manor Green Street
Location	São Paulo, Brazil	Da Ping Village, Sichuan, People's Republic of China	Ljubljana, Slovenia	Kambi Moto community, Nairobi, Kenya	Durban, KwaZulu Natal, South Africa
New build or refurbishment	Refurbishment	New build	Refurbishment	New build	Refurbishment
Number of dwellings	84 units	200 units	371 units in 3 phases between 2008-2011; ongoing work of National Housing Fund to build 600+ social units to Passivhaus standard	270 units	30 home retrofits
Typical dwelling size	26m^2 – 33m^2	Avg. 35m^2	Unspecified/ varies	Est. 58m^2 (three stories on 20-25m^2 plot)	Typically 30m^2 (some have formal or informal additions)
Building cost: for case	US$7,140 per unit	US$76/m^2 US$7,980 – US$13,330 per unit	Total (refurbishment cost) US$1,248,000 (US$3,364 / unit)	Unknown	Total (refurbishment cost) US$86,800 (US$2,893 / unit)
Building cost: business as usual	US$28,000 per unit (Iguape Condo, São Paulo) (social housing)	US$150 - 180/m^2 (for 'normal construction')	US$70,172 per unit (Slovenian Housing Fund and Community of Izola social housing project 2004)	US$18,360 per unit: maximum building cost at which a developer may be exempt from VAT (social housing)	US$2,647 per unit new build social housing (eThekwini typical cost estimate)
Policies and policy instruments	Regulatory and control instruments: Standard building codes	None mentioned	Voluntary labelling and certification: Passivhaus; Legislation for all new private & public building: must be designed to a low energy standard and incorporate renewable energy sources	None mentioned	None, however, the project has a number of policy related recommendations and changes being implemented in the future for South Africa (see GBCSA, 2012).

CRITERIA	CASE STUDY 6	CASE STUDY 7	CASE STUDY 8	CASE STUDY 9	CASE STUDY 10
	The New Generation of Yaodong Cave Dwellings, Loess Plateau	Improved traditional housing in Papua New Guinea	Tiny house villages for USA's homeless	Lisnahull Terrace: Ireland's first certified Social Passive Housing Scheme	Passive Solar Housing in the Cold Desert of the Indian Himalayas
Location	Loess Plateau, People's Republic of China	Papua New Guinea	Various USA	Dungannon, Northern Ireland, UK	Ladakh and Lahaul-Spiti, India
New build or refurbishment	New build	New Build	New build	New build	Both
Number of dwellings	Pilot: 85 units; beyond: 1,000 units	312 house + health and community buildings	11 – 30 units each location; potentially more (ongoing)	5 units	970 units and 30 community buildings
Typical dwelling size	80-100m^2	50-90 m^2	Newfield, NY: 30m^2; Madison, WI: 14m^2 - 37m^2	3 bed: 84m^2 4 bed: 89m^2	Unspecified
Building cost: for case	US$27/m^2 US$2,160 – US$2,700 per unit	US$400-1200/m^2	US$5,000 - $87,000 per unit (differs widely by location and construction)	US$218,179 per unit	Total estimated: US$1.6M
Building cost: business as usual	?	US$1800/m2 (conventional construction)	Varies widely across the USA	US$169,508 – $206,024 per unit (social housing: Ulidia Housing Association, North Ireland)	US$10,106 per unit (Cost to rebuild with prefabricated housing after floods in Uttarakhand)
Policies and policy instruments	None mentioned	None mentioned	Regulatory and control instruments: Standard building codes	Regulatory and control instruments: Standard building codes, Code for Sustainable Homes Level 4, Lifetime Homes, Secured by Design Voluntary labelling and certification: Passivhaus	None mentioned; A first draft of the energy efficient building code has been submitted to the national Ministry for New and Renewable Energy as well as to the local Authorities

CRITERIA	CASE STUDY 1	CASE STUDY 2	CASE STUDY 3	CASE STUDY 4	CASE STUDY 5
Financial models	Low interest (0.7%) 15 year loans repaid by residents monthly	Funded upfront; half costs paid by occupants and half funded by international aid and local government	20% from municipality and 80% from Slovenian Environmental Public Fund loans (repayment is over 15 years at 1%)	Negotiated land tenure of previous informal settlement; community ownership of land; building loans for construction	Majority funded by the British High Commission
Monthly cost to residents	US$74 per month to own	Fuel bills only (owned)	Rent and fuel bills	Loan repayment and fuel bills	Reduction in energy costs (no additional cost to residents)
Subsidies	Low interest rate on loans	Local government and international aid met half the building cost	Local government and Public Fund	No subsidy or external resources for construction costs. All construction costs were met by households alone	No subsidy ('endorsed' by the Dept. of Environmental Affairs)
Sustainable innovations: energy and demand reduction, waste management, etc.	Building reuse; shallow plan to ensure adequate natural ventilation and daylight	Innovative wall tech., material reuse, renewable material use; filtration system provides potable water from mountain spring	Insulation on walls, basement floor and roof; thermal shutters; replaced windows and doors; heat recovery ventilation (MVHR)	Local materials and methods: minimal embodied energy; formal connection to water and sewerage	Insulated ceilings, high albedo roof paint, replaced unsafe electrical wiring, efficient lighting, and heat insulation cookers; rainwater harvesting tanks, and food gardens established
Technical innovations: integration of renewables	None	50% of all energy from renewables: biogas production	Liquid/earth heat exchangers; solar thermal; photovoltaic	None	Solar water heaters (SWHs),
Behaviour change activities	Through a process of participation and social support, residents took on the role of primary decision takers in the design, planning and on-going management of the project.	Sense of ownership and awareness through self-help construction and management	Tenants are individually instructed in how to manage heating systems and to have a greater involvement in the management of their apartments.	The community united, developed skills and worked closely on all aspects of the process – design, planning, saving, construction, project management.	20% use grey water to water gardens; solid waste disposal doubled (less local dumping); potential behaviour related energy reduction (in addition to technical).

CRITERIA	CASE STUDY 6	CASE STUDY 7	CASE STUDY 8	CASE STUDY 9	CASE STUDY 10
Financial models	Completely funded by homeowners with technical support and guidance from the Green Building Research Centre (GBRC)	Private sector contributions mixed with national and international subsidies	Religious and non-profit orgs. raise money, donations (incl. materials), and volunteer hours; one case, Olympia, WA had some state funding	Developer funded; evaluation funded by Technology strategy Board (£28,250)	Half from the EU and FR; other half from foundations, private sector, gen. public. Also carbon credits through the GERES CO_2 Solidaire scheme
Monthly cost to residents	Not specified / fuel bills	Not specified	Rent and fuel bills US$90/ month for 14m^2 - US$375/ month for 37m^2	Rent and fuel bills	Not specified
Subsidies	No state subsidy	National and international subsidies.	State assistance provided in the case of Olympia, WA; some cases land leased from local authority for US$1 p.a.	Not specified	Half of the project funds come from institutional funds from the European Union and France
Sustainable innovations: energy and demand reduction, waste management, etc.	Thermal mass (earth shelter), recycled building materials, solar spaces	Low embodied energy; design to provide natural cooling; composting toilets; rainwater harvesting,	Material reuse, composting toilets, shared bathing and cooking facilities	Triple glazed doors and windows, high performance external elements, minimised thermal bridging, airtight sealing, MVHR	Passive solar orientation and design; thermal mass; insulated to a higher standard to reduce heat demand
Technical innovations: integration of renewables	Solar hot water	Solar power	Solar hot water and photovoltaic depending on case	Solar hot water	Biomass heating already used and reduced through project
Behaviour change activities	Residents were advised on how to take greatest advantage of the new dwellings	None mentioned	Focus is more on social behavioural change	A pre-allocation information meeting for those tenants, pre-handover viewing, tenant User Guides and posters in each home, follow up support	Householders contribute labour and develop skills --- Raising awareness to save energy with local media campaigns reaching an estimated 300,000 persons

CRITERIA	CASE STUDY 1	CASE STUDY 2	CASE STUDY 3	CASE STUDY 4	CASE STUDY 5
Community awareness and engagement	Extensive discussions, workshops and group activities were carried out with residents to promote community co-operation and integration.	Villagers provided construction labour; Villagers responsible for management of the local environment.	None mentioned	Experiencing the results of building efforts on a daily and practical level, the women in the community felt free to speak out on what needed to be improved in the next building phase.	As a COP17 legacy, the Cato Manor Green Street is established as a permanent demonstration and living learning site; residents are trained to be tour guides
Community interactions (e.g. urban agriculture)	None mentioned	Master plan: eco village including organic agriculture	None mentioned	A catering group has been formed and is developing its business.	
Evaluation	Unknown whether evaluation took place	Energy consumption monitoring (3 year monitoring plan)	Energy consumption monitoring, bi-yearly interviews	Method unspecified	Electricity and water consumption, and temperature and humidity monitored; pre- and post-implementation household surveys. Also measured cost benefit, income and quality of life
Source(s)	WHA, 2004; UN-habitat, 2013b	WHA, 2011b	WHA, 2010; ECA, n.d.	WHA, 2009b; Noppen, 2013	GBCSA, 2012; Aucamp and Moodley, n.d.

CRITERIA	CASE STUDY 6	CASE STUDY 7	CASE STUDY 8	CASE STUDY 9	CASE STUDY 10
Community awareness and engagement	People work together with their friends and neighbours to build their own homes.	Participatory planning and building process; Over the course of the project, over 1000 workers were employed and trained in the techniques used.	Example: Having hundreds of residents get to know people that were homeless made a huge difference in the success of the project in Olympia.	None mentioned	Ensuring sustainability by training local masons and carpenters in energy efficient construction techniques
Community interactions (e.g. urban agriculture)	The design of the housing is conducive to people meeting their neighbours	None mentioned	Urban agriculture, communal amenities, e.g. kitchen and showers	None mentioned	Unspecified/ work is done in existing village with community in place
Evaluation	Thermal performance and occupant satisfaction was monitored in the pilot study	Unknown whether evaluation took place	Unknown whether evaluation took place	TSB funded 2 year study: Post Completion and Early Occupancy evaluation, e.g. effective design and build execution and In Use and Post Occupancy evaluation, e.g. energy use, temperature, humidity, and CO_2 levels + qualitative interviews and questionnaires,	Internal and external evaluations including baseline surveys, impact studies, mid-term and end-term evaluations, and an annual general review. Findings are used to inform practice. A regularly measured key indicator for sustainability is the satisfaction of the local community.
Source(s)	WHA, 2006	WHA, 2003; UN-Habitat, 2012a	Lundahl, 2014; Opportunity Village Eugene, 2014; Community First!, 2014; Occupy Madison, n.d.	Constructing Excellence in NI, n.d.; Gallagher, n.d.; URS Scott Wilson, 2012	WHA, 2011a; Firstpost, 2013

Best practice case study locations

Figure 5.1 shows the locations of the international best practice case studies. The templates used to present the case studies in sub-section 5.2 focus first on the environmental, economic and social & cultural sustainability aspects of each case study. These features are followed by supplemental information in addition to the information supplied in the matrix.

FIGURE 5.1 CASE STUDY LOCATIONS

North America
Tiny house villages for USA's homeless, various cities

Latin America and Caribbean
Building Restoration for Social Housing Purposes in São Paulo, Brazil

Europe
Low energy and passive housing in Ljubljana, Slovenia
Ireland's first certified Social Passive Housing Scheme, Dungannon

Sub-Saharan Africa
Self-help housing in the Kambi Moto Community, Nairobi, Kenya

Cato Manor Green Street, Durban, South Africa

Asia
Sustainable Village in Da Ping, China
The New Generation of Yaodong Cave Dwellings, Loess Plateau, China
Passive Solar Housing, India

Oceania
Improved traditional housing in Papua New Guinea

Best practice case studies

Building Restoration for Social Housing Purposes - Celso Garcia, 787

Unification of Tenement- Housing Struggles (ULC) and Integra

São Paulo, Brazil

The city centre of São Paulo is filled with empty buildings while, paradoxically, millions of people live in inadequate conditions elsewhere.

Context

Despite advances in public policies for housing in the last two decades, Brazil's housing deficit is 5.6 million housing units, 63 per cent of which is accounted for by families with a monthly income below US$250. In São Paulo, Brazil's largest city, an estimated one fifth of the population of 17.5 million is currently living in inadequate housing conditions, in favelas (squatter settlements), cortiços (overcrowded tenement housing) or clandestine land subdivisions. In recent years government offices, businesses and financial institutions have left the city centre, leaving 30 per cent of buildings disused or under-utilised. The city centre of São Paulo is filled with empty buildings while, paradoxically, millions of people live in inadequate conditions elsewhere.

This Building Restoration for Social Housing Purposes project works toward the reversal of the process of exodus from the central area, proposing housing alternatives in city areas that have lost part of their population in the last several years yet remain rich in urban infrastructure.

São Paulo, Brazil.

Key features

In 1999, the ULC popular movement for housing (Unification of Tenement-Housing Struggles) occupied a derelict building, formerly a bank branch, in the centre of São Paulo. With assistance from Integra, feasibility studies were carried out, as well as negotiations with the owner and the public authorities, in order to negotiate the purchase of the property and enable the conversion of the empty building into apartments for 84 member families living in inadequate housing conditions.

ENVIRONMENTAL SUSTAINABILITY

- Building reuse: reduce urban expansion and protect unused land
- Revitalisation of city centre; urban location: reduce transportation emissions
- Natural ventilation where the building used to be air conditioned

FINANCIAL SUSTAINABILITY

- Revitalisation of the urban centre increasing its asset base
- Urban location increases employment opportunities of occupants

SOCIAL & CULTURAL SUSTAINABILITY

- Integration and active participation of future residents, including participatory workshops and extensive follow-up support

The project, developed by the ULC in conjunction with Integra, was approved by the public authorities and received funding from the Caixa Econômica Federal (CEF), Brazil's federal savings bank, through the PAR Housing Lease Programme. The $600,000 package covered the costs of purchasing the building, renovating and converting the space into residential units, architectural design and engineering, and social/community development work (provided by Integra). The project involved the creation of 84 dwelling units at an average cost of US$ 7,140 per unit. The costs of the project, funded by the CEF, are repaid by the residents in affordable monthly instalments, which do not exceed 0.7% of the total cost, over a period of fifteen years. Average monthly payments of US$50 are cheaper than the rents charged in cortiços (overcrowded tenement-style housing), which typically range from US$83 to US$100 per month. Residents are responsible for ongoing service and maintenance costs of approximately US$23.50 per month. At the end of the process, resident families lease the housing units from the bank for a period of 15 years, after which time they become owners of their apartments.

Housing units range from 26m² to 33m² and careful steps were taken to ensure that adequate natural ventilation and lighting was provided to each housing unit in the deep-plan, formerly air-conditioned and electrically lit building. Through an innovative process of participation and social support, residents took on the role of primary decision takers in the design, planning and on-going management of the project. Integra, selected by the ULC to take part in this project, carried out a series of activities with ULC members and future residents that included general weekly meetings, meetings with the elected co-ordination committee, work group activities and the creation of a space for discussion on themes ranging from project design and building codes to conflict resolution and community development. The objective was to promote the integration and active participation of future residents, to consolidate public spaces for talks and deliberations and to provide ongoing support without creating a relationship of dependence between the group of residents and the Technical Advisory team.

Innovative Aspects

The project has resulted in improved housing conditions and increased opportunities for an excluded segment of the population. The provision of adequate natural ventilation and lighting has resulted in improved health conditions, particularly among children. The project has greatly reduced the vulnerability of residents as it follows strict building codes.

- Recycling of derelict buildings in the city centre into affordable housing for social purposes, making use of existing buildings and urban infrastructure.
- Provision of housing for low-income sectors of the population (residents were either homeless or living in inadequate housing conditions) in central urban areas, close to the workplace.
- Articulation of Urban Popular Movements for housing with local public authorities, the CEF and the building owners.
- Innovative social approach, involving participatory workshops with future residents and extensive follow-up support
- This is the first project within a national housing programme to involve change of use (commercial to residential) (WHA, 2004).

Sustainable Village - Post-earthquake reconstruction and rehabilitation in Da Ping

Green Building Research Centre

Da Ping Village, Sichuan, People's Republic of China

The entire village, including more than 200 houses and 11 public buildings, was reconstructed using traditional construction methods and environmentally sustainable materials and design.

Context

Despite the abundance of food, Sichuan remains a poor part of China with many of its working population having moved away for work, leaving the poor and elderly behind. Housing is typically of inferior quality, with poor natural lighting and environmental performance. Brick masonry structures, constructed by householders trying to imitate urban dwellings, are not seismic resistant. The Wenchuan Earthquake measuring 8.0 on the Richter Scale struck China on 12th May 2008,

Da Ping Village, Sichuan, People's Republic of China.

ENVIRONMENTAL SUSTAINABILITY

- In depth analysis of local conditions for design development
- Constructed of locally abundant timber and bamboo
- All reusable material salvaged an reused from damaged buildings
- Performed post-occupancy surveys including resident satisfaction surveys and monitoring of energy consumption
- Over fifty per cent of all energy comes from renewable sources (includes wood fuel and bio-gas production)
- Post-construction support includes local green planting, ecology and continued village environmental management

FINANCIAL SUSTAINABILITY

- Construction based on local timber-frame method which villagers were accustomed to building and maintaining
- Material reuse – reduce building costs
- Significant reduction in household fuel bills

SOCIAL & CULTURAL SUSTAINABILITY

- Consultation with residents prior to design and development
- Provision of community centre providing space for training in organic agriculture, construction and medical treatment
- Local building knowledge improved through help of qualified engineers throughout building process
- Modern farming and hygiene improvement methods were taught to the villagers through organic agriculture, site planning (distancing dwellings from livestock), sanitation management, and potable water filtering system
- Project established community led and managed enterprises to generate wealth

causing extensive damage and killing 70,000 people. In Da Ping Village, less than 30km away from the earthquake's epicentre, virtually all houses were damaged or collapsed in the earthquake. Earning a living in the devastated town became impossible. Temporary housing provided after the earthquake was insufficient, but seemed the only option due to the rapid increase in construction material costs.

Key features

Over 200 houses and 11 public buildings were built on the same site as the original settlement using environmentally sustainable materials and design. A five-stage process was used, with in-depth analysis of local conditions and consultation with residents prior to design and development, followed by post occupancy surveys, including resident satisfaction surveys and monitoring of energy use.

Fifty per cent of the population earns less than US$1,050 per annum, so low cost construction was essential. The average house cost was less than US$76 per m^2 and with a typical size of $35m^2$ per person typical house prices ranged from US$7,980 for a three-person household to US$13,330 for a five-person household. This compares to US$150 per m^2 to 180 per m^2 for normal construction and is significantly lower because the villagers used their own labour and local timber as well as salvaging materials. Costs were met from a combination of residents' savings, and grant aid from the Red Cross as well as the local government. Overall, donations from the Red Cross and the government accounted for half of the total cost, the villagers self-contribution accounted for the other half.

Innovative Aspects

- The creation of an ecological village master plan developed on sustainable design principles.
- The project retains the traditional way of life and spurs development of the local economy by harnessing local resources in an environmentally sensitive manner.
- Core house and module concepts are used to enable flexible design options. Once the core house is finished, spaces can be added as needed for further living requirements.

Lessons Learned

- The initial fast-built demonstration units are essential in winning over residents to new ideas.
- Intense involvement of the local villagers was crucial to the success of the project.
- The module design concept can meet the demands of a variety of families.
- A subtle balance between architectural form and thermal performance should be sought when it comes to local material selection.
- The use of low technology solutions makes self-help and mutual help possible, encouraging a sense of ownership and identity, as well as facilitating transfer to nearby villages.
- There needs to be a balance between social acceptance and architectural performance, so that the cost, architectural form and comfort are easily acceptable by the occupants.

Transfer of ideas

- Plans and construction drawings have been sent out following multiple requests
- The methods developed in Da Ping Village were also used in Yushu County, Qinghai (120 homes provided in seven months), when an earthquake struck in 2010; in constructing new nomadic accommodation for Tibetan herdsmen in Gangcha County, Qinghai (100 homes); in Yinchuan City, Ningxia, in the northwest desert region (80 homes).
- Residents from nearby villages have visited, learned from and emulated Da Ping
- A commercial developer is looking at the possibilities of replication near Xi'an (WHA, 2011b).

Low energy and passive housing in Ljubljana

The Public Housing Fund of the Municipality of Ljubljana

Ljubljana, Slovenia

The main aim is to improve the energy consumption in rental apartments in the municipality of Ljubljana, by both retrofitting existing housing stock and by building low energy/passive housing.

Context

Projects have been undertaken to reduce housing and maintenance costs and enhance the quality of living conditions in municipally-owned non-profit rented dwellings in degraded parts of the city. The main activities of the project are to refurbish the existing housing stock and to construct new stock that is energy efficient.

Key features

The first project carried out was the refurbishment of an existing block where 57 apartments were created in an existing building with high levels of energy efficiency. The work included putting insulation on the external walls, basement floor and attic ceilings, and replacing windows and doors with energy efficient versions with external thermal shutters. Other projects followed with added benefits such as mechanical ventilation systems with 75 per cent heat recovery. As a result of all the retrofit work, energy consumption fell by nearly 40 per cent. Other projects followed including four new-build developments providing a total of 234 new apartments built to the PassivHaus standard in 2011. This standard uses high levels of insulation, careful design and mechanical ventilation to ensure that the total energy demand for space heating and cooling is less than 15 kWh/m²/yr treated floor area, and that the total primary energy use for all appliances, domestic hot water and space heating and cooling is less than 120 kWh/m²/yr.

ENVIRONMENTAL SUSTAINABILITY

- Wherever possible used materials with low embodied energy
- Reduction in energy usage and carbon emissions
- A range of technologies are used including heat recovery ventilation units, pre-cooling and pre-heating of air with liquid earth heat exchangers, solar thermal and PV systems.
- Brownfield site development: reduces the need for transportation and the other negative aspects of urban sprawl.

FINANCIAL SUSTAINABILITY

- Additional temporary jobs have been created through the construction programmes
- Urban location increases employment opportunities of occupants
- Significant reductions in energy bills for residents as a result of the energy reduction

SOCIAL & CULTURAL SUSTAINABILITY

- Tenants are instructed in how to manage heating systems and have a greater involvement in the management of their apartments
- The improved quality of accommodation in the social rental sector improves the status of social housing tenants; living in some of the better accommodation in the neighbourhood helps to increase self-esteem.

Ljubljana, Slovenia.

A range of resources have been deployed by the municipality to carry out the refurbishment work to date. These include the municipalities' own resources (20%) and loans from the Slovenian Environmental Public Fund (SEPF) (80%).

Impact

- These projects are carried out in degraded parts of the city and have had positive socio-economic impacts on surrounding areas.
- Fuel consumption and the associated carbon emissions have been reduced and a greater awareness of the need to save energy has been developed, in both the private and social housing sectors. Schools and kindergartens are also being built to low energy standards.
- Legislation has been passed to ensure that all new buildings in the city, both private and public construction, must be designed to a low energy standard and must incorporate renewable energy sources available on site. In addition, the building design must include an assessment of how these requirements will be fulfilled.
- Ljubljana City policies now have a much greater emphasis on urban sustainability, addressing urban issues such as sprawl, public transportation etc. The example, the capital city is increasingly being taken up by other towns and cities in Slovenia.

Lessons Learned

- Every project is different and every project needs special analysis, not only in respect of the site capacity but also in terms of future users of the buildings. It is essential to involve tenants in all discussions at every stage, in order to ensure that they have maximum information on how to best use and live in the dwellings and thus maximise their energy savings.
- The need for teamwork is important throughout the project, but especially during the design and construction phases.

Evaluation

- The overall energy consumption in the blocks is being monitored on a regular basis, including online monitoring in the newest flats. Residents are contacted twice a year during periods of maintenance and are interviewed during these visits to monitor occupant satisfaction.

Transfer of ideas

- Exhibitions, guided tours, presentations and workshops have encouraged other organisations to consider their ideas and approaches, especially in the private sector, where commercial investors found that social housing was offering higher standards than they were.
- The development of an EI-Education programme for social housing companies and a practical guidebook for social housing companies on energy intelligent retrofitting are both ongoing initiatives.
- The Slovenian experience has been shared with the other EU cities participating in the REBECEE programme (Alingsas, Kiel, Riga, Tallinn, Sofia and Vilnius) (WHA, 2010).

Technical team planning for self-help housing in the Kambi Moto Community

Kambi Moto community

Nairobi, Kenya

This programme was developed to enable the 270 households of Kambi Moto informal settlement to gain security of tenure and to design and construct their own homes, whilst simultaneously developing their skills in procurement and project management procedures.

Context

60 per cent of the inhabitants of Nairobi live in informal settlements. In Kenya, the professional services of architects and engineers are not affordable for a majority of the population. Although the urban poor show impressive improvisation skills and innovation to better their housing situation, there is a need for value that can be added by the technical and design professions.

Kambi Moto means 'place of fire' and is so called because the high density of housing structures made from wood and scrap materials have burned down on several occasions. The households have remained in this overcrowded location due to its proximity to the city's infrastructure and livelihood opportunities. Typically for this kind of informal housing situation, the inhabitants include so-called structure owners, who act as landlords for up to 30 shacks and receive their income from tenants who often have to pay exorbitant rents for their (inadequate) shelter.

Key features

The Technical Team, working in conjunction with local NGO the Pamoja Trust, Nairobi City Planning Department and both universities in the city, engaged with the residents of Kambi Moto. The Technical Team is an informal network of professionals (architects, planners and surveyors) working alongside communities of the urban poor to enable them to build their own homes and gain security of land tenure. Further, by training the community on procurement procedures and management of the projects, these tasks can be adopted by community members, minimising future long-term reliance on professional input.



Nairobi, Kenya.

ENVIRONMENTAL SUSTAINABILITY

- Locally available lava stone blocks were used as building materials for the new homes, rather than cement blocks.
- Floor slabs and roof terraces were built with pre-fabricated concrete mini-floor slabs that use a fraction of steel and cement compared to conventional concrete.
- The planning of the settlement took into account the local knowledge of the site and conditions when considering natural storm-water run-off, path and road access.

FINANCIAL SUSTAINABILITY

- In order to reduce the labour costs, the households themselves provide unskilled labour. In so doing, the future tenants developed labour skills.

SOCIAL & CULTURAL SUSTAINABILITY

- Due to the learned skills, the community members are now applying and qualifying for formal construction work outside the settlement.
- A catering group has also been formed and is developing its business.
- The community has come together, developed skills and worked closely on all aspects of the process – design, planning, saving, construction, project management and sharing their experience through exchanges with other communities
- The community members have become better leaders and are equipped to articulate their needs clearly to the city council.

The original informal plot was transferred to the community as a whole, and each household receives a sectional title, meaning that if a family wishes to sell up then their title is sold back to the community. All construction-related costs and 80 hours of labour are met by the households themselves. Ten per cent of the construction cost is a down-payment from the individual family, typically covered by savings, paid into the community savings scheme during the preparation stage; 90 per cent of the construction cost is given as a loan. The construction has been carried out incrementally and in-situ so that the households did not have to move out of the community. During each construction phase between 20 and 30 homes are built. Therefore only a small number of the community are affected and can be accommodated by their fellow community members.

Innovative Aspects

- The community has been empowered to own and manage the whole process, developing skills and increasing capacity as they go.
- The local professionals involved in this project received training and motivation to work locally and enhanced their skills by providing better service to the community-built housing process.
- The innovative urban layout that combines the pedestrian nature of the settlement with access for emergency vehicles has enabled all the 270 households to stay on site.
- The phased construction process (20 to 30 houses) has reduced disruption, benefit from bulk buying of materials, and has also enabled learning to be passed from one phase to the next.
- The choice of locally available stone and components fabricated on site has reduced the need for expensive, energy-intensive materials (for example cement and steel) and has involved training community members to produce materials, providing skills and an income.

Transfer

- The ongoing community-led process of negotiation on every issue from the design through to the conditions for loan repayment has served as a real and positive example for other communities and technical professionals in Huruma and across Nairobi.
- The community of Kambi Moto is and will be assisting other urban poor communities in Nairobi and other towns in their struggle to enhance and secure their housing situation.
- Knowledge transfer exchanges have taken place between professionals and between communities in Nairobi. Community members from Kambi Moto have supported other community building teams in Uganda and South Africa, and have shared their experiences in Asia through SDI exchanges.
- Other informal settlement upgrade schemes across Nairobi (e.g., Gitathuru and Mahira in Huruma district) have learnt from this process, both from a design and implementation perspective (WHA, 2009b).

Cato Manor Green Street

Green Building Council of South Africa

Durban, KwaZulu Natal, South Africa

In the Cato Manor Green Street, each household received an energy and water efficient retrofit. In addition, food gardens were established for the production of healthy, home grown food. The polluted stream in the area was cleaned up and indigenous / fruit trees and smaller plants were planted. This project was the first of its kind in KwaZulu Natal, and one of the first in the country, with such a broad set of interventions in one place.

Context

The South African government has built almost 3 million low-cost homes since 1994 and a further 3 million are targeted by 2025. Cost-cutting has been common to maximize delivery, but unfortunately this has meant that these homes have generally been designed and constructed with no water heating system, and little regard for energy and water efficiency, adequate insulation or other 'green' design considerations. For this reason people living in these houses continue to spend significant amounts of their income on energy, while suffering disproportionate health burdens.

A few pioneering pilot projects like those in Joe Slovo, Kleinmond, Kuyasa and Witsands in the Western Cape, Cosmo City in Gauteng, and Zanemvula in the Eastern Cape have demonstrated the economic and societal benefits of more sustainable design in low-income housing. Not only do green interventions translate into energy, water and financial savings, but also reduce associated illness, safety risks, greenhouse gas emissions and environmental impact. The South African government has recognised the pressing need for more sustainable housing programmes.

Key features

The project involved consultation with local government to provide support and equipment, e.g. LED streetlights, clean-up campaign, environmental monitoring devices for monitoring stage, etc. Further consultation took place with the community to ensure co-operation and interest in the project. Among other upgrades, the retrofit involved installing insulation in the ceilings, electrical upgrade, and solar hot water systems long with the required plumbing. The project included a monitoring and analysis stage which focussed on impact, notably electricity use, water use, comfort, cost-benefit and quality of life. Learning from the project has been used to make important policy recommendations for the construction of new homes, the retrofitting of existing houses, and the scaling up of key interventions.

ENVIRONMENTAL SUSTAINABILITY

- Solar hot water
- Insulated ceilings and low albedo roof coating
- Energy efficient lighting and complete re-wiring of electrical for safety
- Heat retention insulation cookers
- Rainwater harvesting systems
- Water efficient plumbing
- Food gardens
- Clean-up and rehabilitation of local stream
- Indigenous plants replace invasive plants
- Solid waste disposal intervention

FINANCIAL SUSTAINABILITY

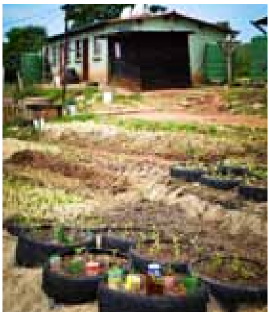
- Permaculture and food gardening training
- Food costs decreased for a number of residents
- Onsite job training
- Home prices increased

SOCIAL & CULTURAL SUSTAINABILITY

- Community consultation
- Permaculture and food gardening training
- Increased sense of community ownership

Innovative aspects

- Hot water on tap for the first time through solar hot water systems where before many residents could not afford the energy to heat water.
- Energy reduced by 25%.105 tonnes of carbon have been avoided, and the sale of carbon credits will generate funds to be invested back into this community.


Durban, KwaZulu Natal, South Africa.

- Greater human comfort and aesthetics inside homes, and improved health and safety. Peak temperatures on summer days have dropped by 4-6°C with insulated ceilings. Overall internal discomfort levels have dropped. Less need for fuels like paraffin, coal and wood mean reduced health problems and fire safety risks for these homes.
- Training and work opportunities were created. A range of practical, on-the-job training sessions and community education workshops were conducted.
- Water and food security increased for residents. The additional rainwater supply harvested boosts water security, especially in times of erratic rainfall or droughts, and will keep water costs down in periods of municipal water shortages. Rainwater is mainly used for laundry and for watering food gardens. The tanks hold about 30,000 litres over an average year of current-level rainfall, which is more than three months' worth of free basic water allocation. Water use is efficient, and grey water is also being used for food gardens. Sixty percent of homes say that they are saving on food costs (GBCSA, 2012).

The New Generation of Yaodong Cave Dwellings, Loess Plateau

Loess Plateau, People's Republic of China

Over 1,000 affordable, environmentally sustainable dwellings have been built in the Yaodong cave area using traditional energy saving methods, vernacular housing design, innovative solar energy systems, and natural ventilation methods help to reduce energy consumption.

Context

Located in north central China, the Loess plateau of undulating hills covers nearly 500,000 km^2. Forty million people live in this region, 75 per cent of whom are farmers in rural areas. Living conditions are amongst the lowest in China. Ninety per cent of the rural population live in various types of yaodong, or cave dwellings. The earliest types of these were dug into the hillsides and they have since evolved into masonry dwellings that are more disengaged from the mountainside (only 10 per cent are still in the dug-out form, 70 per cent have their rear wall abutting the mountainside and the remainder are entirely freestanding).

ENVIRONMENTAL SUSTAINABILITY

- Local topography provides housing structure, thereby reducing the need for roofing and wall materials. The building materials used are sourced locally and recycled building materials have been used wherever possible.
- Earth shelter thermal mass maintains even temperatures throughout the year.
- Solar space provides heat and daylight - CO_2 emission saving per property is 2,400 kg (2.4 tonnes) for a 100 m^2 dwelling.

FINANCIAL SUSTAINABILITY

- The costs of the new dwellings are approximately half of that of the new flats being built using western methods and materials in the nearby towns
- Utility bills are lower as a result of reduced need for heating

SOCIAL & CULTURAL SUSTAINABILITY

- Retaining young people in the area with more modern and inexpensive housing helps boost the local economy and prevents rural depopulation.
- People work together with their friends and neighbours to build their own homes. The design of the housing is more conducive to people meeting their neighbours than living in one of the new flats in the local towns.
- The houses are cut into hill terraces on land that is infertile or hard to farm, thus maintaining the amount of land available for agriculture.

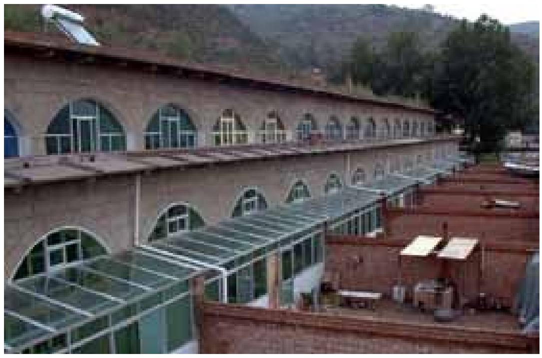
With the rapid growth of China's economy, most rural people want to live in new, modern housing and tend to be dissatisfied with the traditional yaodong dwelling. As they become wealthier, many younger people prefer to build concrete structures where there is a large increase in energy usage and pollution, valuable farm land is used and there are impacts on the natural ecosystem.

Key features

Starting with a pilot project of 85 houses in Zaoyuan village (1996-2001), the project has now seen the development of over 1,000 dwellings by families using self-help construction methods in both rural and suburban areas. In addition, a private real-estate developer has built a further 1,200 dwellings plus two large hotels.

The new housing design is based on the traditional design but increases the one-storey yaodong to two-stories and includes a sunspace at the front and earth-sheltered roofs, which serve to increase the indoor daylight levels, as well as improving natural ventilation and humidity. The houses have roof planting and thermal mass. Although the houses are low-cost they are sufficiently modern to be attractive to the local people. Innovative solar energy systems and natural ventilation methods have been successfully introduced whilst still retaining the traditional arched yaodong front which has cultural significance.

The sense of cultural continuity is very important. Surveys have shown that the residents feel that the new yaodong is not something imposed on them from the outside, but rather it has grown out of their lives and is a continuity of their building tradition. Local people are involved throughout the design and construction process and friends and neighbours of the residents help build the houses, using traditional building skills.



Durban, KwaZulu Natal, South Africa.

The resident's subjective opinion of the new dwelling and involvement in the design and construction process is considered to be an important aspect of the sustainability of the housing, of equal importance as the energy- and pollution-saving aspects.

Innovative Aspects

- Establishing a new typology for the rural population that is connected to local and traditional roots, but that meets changing social and economic circumstances and expectations.
- Use of two-storey construction rather than single-storey in order to increase the amount of functional space available.
- Zero consumption of energy for heating, ventilation and air conditioning due to the use of thermal mass, solar energy and natural ventilation systems.
- Recognition of the value of the residents' input into the design and construction process.
- Environmental monitoring found that indoor temperatures are higher on average by five degrees in the new buildings (i.e. increasing from 10 to 15 degrees at midday) and indoor daylight levels and ventilation are much improved in the new buildings.

Lessons Learned

- Residents need to be advised on how to take greatest advantage of the new dwellings and demonstration houses are important in winning over local residents to new design ideas. An entirely local design process is impossible because residents equate modern, non-local building materials with progress and an increase in status.
- Ecological principles need to be applied differently in urban and rural areas since there is greater emphasis in the rural areas on retaining some of the traditional design values. High tech solutions and expensive methods are not appropriate in these rural areas. Promoting low-tech solutions will not win local residents over unless there is a significant increase in living conditions (WHA, 2006).

IMPROVED TRADITIONAL HOUSING IN PAPUA NEW GUINEA

Joint work between Community Based Building Program Ltd, SPK Projects, Niugini Works, and Assaí

Papua New Guinea

Traditional design and construction systems have been adapted to meet modern housing needs in Papua New Guinea.

Context

Papua New Guinea (PNG) is located in the Pacific Ocean and with a population of seven million has a population density of 10 people per km^2. 17 per cent of the population live in urban areas. The vast majority of housing in PNG is rural housing on traditional land. Other housing types are government housing for teachers etc., urban squatter settlements and private housing. In general, both housing finance and land are very difficult to obtain. Although PNG possesses a rich traditional building heritage suited to the local material base, climate, skills base, economy and way of life, this is increasingly being supplanted by an imported modern architecture that is unfamiliar to the local way of life, often very expensive and prone to rapid deterioration due to poor design and inappropriate materials choice.

Project Description

The aim of the project was to develop a new and constantly evolving form of housing for Papua New Guinea which maintains the inherent traditional architecture that is climatically, culturally, economically and ecologically appropriate and sustainable. Furthermore to meet the modern housing need the housing must be competitive with modern methods and easily taught, learned and replicated.

Sustainably sourced timber, along with other locally sourced material, is used throughout the project with an emphasis on affordability, durability and local income generation opportunities. In addition housing for low-income earners, the project included high-income houses in an effort to increase the status of traditional design with lower income earners. The natural materials used and designs developed are appropriate for the climatic conditions and produce a healthy living environment compared to the air-conditioned houses that are built otherwise. Traditional building skills are retained and enhanced through the building process and through general confidence and capacity building.

ENVIRONMENTAL SUSTAINABILITY

- Design of houses using traditional methods provide a naturally cool house, excluding the need for air conditioning
- Dry composting toilets
- Solar power
- Rain water harvesting
- Natural, local, sustainably sourced materials

FINANCIAL SUSTAINABILITY

- Costs are reduced beyond half the price of non-traditional housing with imported materials and methods
- Labour (building and material supply) contribution from occupants

SOCIAL & CULTURAL SUSTAINABILITY

- Residents play and active role in the planning and building process
- New approach is taken to culturally sensitive, traditional methods of construction for housing.

Papua New Guinea.

The Assai design philosophy is to preserve and adapt the traditional building culture in the face of modernisation and inappropriate western housing models. The approach used by Assai was to analyse traditional PNG architecture, to understand and maintain its value and change it only where it is necessary to respond to new demands for mosquito proofing, cleanliness, electricity, water, sanitation, privacy and the car. As an example, iron roofs replaced the traditional thatch roofing whilst retaining the original form and slope to provide shade, rain shedding and a cooling air volume for the interior. The iron roof allows for rainwater harvesting and is longer lasting than the thatch roofs which are flammable and susceptible to vermin. Another key feature of the design includes single lined wall frames with a latticed infilling which allow an increased amount of light into the house for important tasks.

Residents were involved as key participants in the development process. Each housing project is designed with extensive end user consultation through a workshop process. Workshops were first held at the 'pattern' level, i.e. looking at what in general a house in this area should be like and secondly with the residents as part of the detailed design process. This approach has also been used for schools and other community buildings in the area.

Innovative Aspects

- Use of traditional architecture as a prime driver for design and construction.
- Focus on developing a sustainable and appropriate language of design and system of construction.
- Emphasis upon affordability, durability and build-ability.
- Involvement of residents as key participants in the development process.
- Adoption of an open and inclusive philosophy towards knowledge exchange and intellectual property.

Sources: *WHA, 2003; UN-Habitat, 2012a*

Tiny house villages for USA's homeless

Newfield, NY; Olympia, WA; Madison, WI; Eugene, OR; Austin, TX USA

A collaboration between the housed and the unhoused providing stable, safe, and sustainable places to live through alternative, cost-effective approaches for transitioning the unhoused to more permanent living situations (Opportunity Village, Eugene).

Context

More than 3.5 million people experience homelessness in the United States of America each year. Shortages of low-income housing continue to be a major challenge. For every 100 households of renters in the United States that earn "extremely low income" (30 percent of the median or less), there are only 30 affordable apartments available. In the USA homelessness can be seen in every city while typical houses are some of the largest in the world. The tiny house movement is growing in many areas throughout the USA providing people with significantly reduced construction and living costs. Whereas, for example, the typical development for low-income housing is around $200,000 per unit in Washington State, these small homes are a fraction of that cost. Also as a result of the size and shared amenities, carbon emissions are also reduced.

Newfield, NY; Olympia, WA; Madison, WI; Eugene, OR; Austin, TX USA

ENVIRONMENTAL SUSTAINABILITY

- Composting toilet
- Solar power
- Onsite vegetable garden and chick coop
- Communal washing facilities reduce water heating load

FINANCIAL SUSTAINABILITY

- Small space to heat
- Onsite vegetables and eggs help occupants raise inexpensive food
- Extremely low rent, e.g. $90 a month for a 150 sqft home to $375 for 400 sqft.

SOCIAL & CULTURAL SUSTAINABILITY

- Communally located for support and social interaction
- Skills development – occupants are assisted in construction process
- Residents are required to avoid drugs and alcohol and help maintain the properties.

Project details

In a number of cities throughout the USA religious and other non-profit organisations are building small homes for the homeless people in their cities. This is being done without financial help from the local authorities, i.e. taxpayer money (with the exception of Olympia).

Innovative Aspects

- Land, materials and labour donated.
- Communally focussed housing with gardening space (innovative for the USA)
- The residents in the developments have a common space with shared showers, a laundry, garden space, and a kitchen (amenities vary by project). By sharing these amenities, the community was able to increase the affordability of the project and design a neighbourhood they believed would fit their needs and make them more self-sufficient.

TABLE 5.2 CASE STUDY DETAILS OF FOUR DEVELOPMENTS (LUNDAHL, 2014).

	Newfield, NY	Olympia, WA	Madison, WI	Austin, TX
Residents	18	30	15	200
Houses	18	30	11	undecided
Cost per house	$12,000 +labour	$87,500	$5,000	$30,000

- In Madison the communal building is a converted petrol station.

Challenges

- The project in Olympia was held up in court for a year by a local organization of businesses and landowners called the Industrial Zoning Preservation Association, which cited concerns over the potential impact on local businesses in a nearby industrial park.
- Local residents in Madison are concerned about the new occupants moving in across the street because of commonly held misunderstandings about the homeless.

Lessons Learned

- Having hundreds of residents get to know people that were homeless made a huge difference in the success of the project in Olympia.

Sources: *Lundahl, 2014; Opportunity Village Eugene, 2014; Community First!, 2014; Occupy Madison, n.d.*

Lisnahull Terrace, Dungannon - Ireland's first certified Social Passive Housing Scheme

Oaklee Homes Group

Dungannon, Northern Ireland, UK

Lisnahull Terrace, Dungannon are amongst the most energy efficient homes in Northern Ireland. The innovative development is the first social houses to be built and certified Passivhaus.

Context

The UK is legally obligated to meet an 80% carbon reduction by 2050, in the domestic sector; this means all new housing must be zero carbon from 2016. Building regulations have been slowly notching up toward that goal since 2006. For the social housing developer, Oaklee, this meant all new homes had to be designed to meet a number of standards: in addition to planning and building regulations they had to achieve Level 4 of The Code for Sustainable Homes, Lifetimes Homes, Secured by Design and meet Northern Ireland Department for Social Development (NI DSD) Guidelines.

Dungannon, Northern Ireland, UK.

ENVIRONMENTAL SUSTAINABILITY

- Triple glazed doors and windows, solar shading brise soliel on large south facing windows to minimise overheating, low U-values on all external elements, continuous insulation, structural insulated panels and foamglass blocks at junctions to avoid thermal bridging, airtight sealing, mechanical ventilation with heat recovery
- Solar passive design: all services and circulation located on north side of building, with habitable rooms on south.
- Solar hot water system

FINANCIAL SUSTAINABILITY

- Reduced energy bills through reduced need for heating and lighting.

Oaklee was well equipped to meet the challenge as they developed the first homes in Northern Ireland to Level 4 of The Code for Sustainable Homes and was at design stage with properties elsewhere to meet Code Level 5. The Lisnahull site is on the western outskirts of Dungannon was an area with high housing need.

Northern Ireland experiences the highest level of fuel poverty in the United Kingdom with households spending significantly more of their disposable income on energy costs. For social housing tenants, in particular, rising energy costs can have a disproportionately devastating effect.

Project details

The site was ideally suited to passive design in that the homes could be planned on a south facing plot with deciduous trees along the southern boundary which would help with shading. The terrace was therefore orientated along an east-west axis to ensure that one facade would be facing directly south to maximise solar gains and accommodate solar panels. Car parking and the front covered entrance from the Lisnahull Road face north with limited windows to this elevation. The development consists of two house types - three 5 person/3 bed and two 6 person/4 bed terraced houses.

The Department for Social Development is responsible for tackling fuel poverty and the Lisnahull project will be used to provide practical learning for future social housing developments.

Challenges and lessons learned

It has been well established that occupant behaviour can create a scenario where designed expectations are never achieved; if tenants fail to use their homes as designed then the potential financial savings will not be achieved. Occupants do need a reasonable level of understanding of a Passivhaus building in order to optimise comfort and performance, however as the tenants were selected from the Northern Ireland common waiting list lifestyles and environmental awareness etc. could not be factored into the selection process. Whilst this could be viewed in a negative way and as a potential risk to the schemes success, it also has a number of benefits, primarily a realistic view on how a home is lived in and experienced. A number of means were used in order to reduce the risk surrounding tenant lifestyles, for example:

- A pre-allocation information meeting for those tenants on the waiting list
- Advanced opportunity to view the homes
- Pre-handover viewing

- Tenant User Guides and posters in each home
- Industry Open Day
- Follow up support

One particular challenge was the language barrier with only two of the five families having English as their first language. Interpreters were used on a number of occasions and at times communication had to be via family members acting as translators.

In monitoring a serious challenge for the developer was with unregulated energy loads. Though through the Passivhaus Standard the goal is to meet a total energy demand for appliances, hot water, and space heating and cooling at or below 120 kWh/m^2 per year, occupants may use any and as much energy for unregulated energy loads, e.g. televisions, computers, fish and reptile tanks, etc.

Evaluation

Oaklee Homes Group successfully applied for funding from the Technology Strategy Board through their Building Performance Evaluation Competition and received funding for monitoring the Lisnahull development as part of both Phase 1 (Post Completion and Early Occupancy) and Phase 2 (In Use and Post Occupancy) studies. The study period will last for over two years.

The study of these homes will include analysis and testing of, design reviews and thermal imaging, commissioning process and effectiveness, the provision of extensive monitoring and metering with regular reports on performance, including areas such as energy use, temperature, humidity, and CO_2 levels. There are also qualitative surveys, interviews and questionnaires, carried out as part of the study with residents providing feedback on their homes.

Sources: *Constructing Excellence in NI, n.d.; Gallagher, n.d.*

Passive Solar Housing in the Cold Desert of the Indian Himalayas

Groupe Energies Renouvelables, Environnement et Solidarites (GERES India)

Kargill District; Leh District, Western Indian Himalayas

Technical innovation in the use of energy efficiency techniques, which combine passive solar features, thermal mass and thermal insulation with local materials

Context

The Western Himalayas is a cold desert with 300,000 inhabitants living in high altitude villages. Natural resources are very limited and local employment focuses primarily on livestock breeding and subsistence agriculture. During the winter, temperatures generally fall below -20°C. Traditional houses are built of wood and stone and are thermally inefficient, with room temperatures falling below -10°C in winter. Family members tend to live together in one room in winter which facilitates disease transmission and the use of stoves aggravates respiratory infections. Large intergenerational households are not uncommon, with 15 members sometimes living in one house.

The target population is individuals living with less than one dollar a day. Scarcity of local fuel and the high price of imported fossil fuels have resulted in a situation of energy vulnerability. Women and children spend almost two months a year gathering dung and bushes in pastureland. Very few activities are possible during winter, even indoors, due to the cold temperatures, however, the region benefits from strong sunlight for more than 300 days per year.

Key features

The passive solar housing technologies used in this programme of new housing construction and retrofitting include solar gain (direct gain, solar wall, attached greenhouse), thermal mass and insulation (window, wall, floor and roof). In the passive solar houses, the average indoor temperature remains continuously above 5°C as

Solar wall in Kargil District.

Direct Gain in Leh District.

ENVIRONMENTAL SUSTAINABILITY

- Passive solar construction techniques
- Locally available and renewable insulation materials: sawdust, straw and wild grass
- Greenhouse gas emissions reduction of 2.5 kgCO_2 per household per year (1.3 tonnes of biomass per household per year saved)

FINANCIAL SUSTAINABILITY

- At the end of the project it is expected that the trained, skilled artisans (in solar passive design, masonry and insulation) will be able to generate income independently as their technical skills and marketing competencies will be sufficiently developed to continue without external support
- Cost savings from more efficient homes
- Less time spent collecting biomass for heating translated to more time for income generating activities

SOCIAL & CULTURAL SUSTAINABILITY

- Community buildings have been provided using the same techniques
- Twelve grassroots-level networks have been established to date consisting of village representatives, masons and carpenters who work together to promote passive solar housing. In addition to encouraging participation, the networks act as a pressure group to advocate for improved local government policy in respect of renewable energy.
- Less time spent collecting biomass for heating translated to more time spent in community improvement and social activities

opposed to -10°C in unimproved houses. Fuel consumption has reduced by 50 to 60 per cent. The average cost of installing energy efficiency features is US$955 and households provide approximately US$610 (64 per cent) of this in cash and kind through local materials, casual labour, part of the skilled labour, and part of the cash materials. Benefits include improved comfort, more social visits, time saving, easier education and improved health. Local people have been trained in income generating skills which include local handicrafts.

Impact

- As a result of the project, people have the benefit of a warmer and healthier indoor environment and they are able to earn more money in the winter months.
- There is a broader awareness of environmental issues due to the large media campaigns on both energy efficiency and climate change.
- Development of a first draft of the energy efficient building code has been submitted to the national Ministry for New and Renewable Energy as well as to the Local Authorities.

Innovative Aspects

- Technical innovation in the use of energy efficiency techniques, which combine passive solar features, thermal mass and thermal insulation with local materials.
- Ensuring sustainability by training local masons and carpenters in energy efficient construction techniques: 215 local masons and carpenters have been trained and over 460 artisans have been provided with training to improve income generation skills.

Lessons Learned

- Dynamic and convinced masons are key elements in the project's success, as they become promoters of the concept and future sustainable development.
- It is easier to generate demand for solar gain techniques (visible and fashionable) than insulation techniques.
- Promotion of passive solar housing through radio programmes is extremely effective.
- Constant monitoring of the construction process, whilst time-consuming, is essential to ensure good quality work.

Transfer

- Spontaneous demands for passive solar houses from outside the project villages have already emerged in the area, from individuals, NGOs and local governments.
- Extensive documentation about passive solar housing has been created and distributed in many local and foreign languages, as well as being available online (WHA, 2011a).

Summary: learning from the case studies

Every project is different and every project needs special analysis, not only in respect of the site capacity but also in terms of future users of the buildings. It is essential to involve tenants in all discussions at every stage, in order to ensure that they have maximum information on how to best use and live in the dwellings and thus maximise their energy savings and future prospects.

Design and planning

- If relocating, location in areas well served by transportation is important for access to potential work, schools, and healthcare.
- Serious consideration for upgrades must be made when bringing occupants out of slums or conditions where they were not previously responsible for fuel, water or sewage bills.
- Keep the design simple but adaptable and flexible; test the designs on various sites to ensure they can respond to differing site contexts.
- Always speak with clients about life cycle costs, not just the initial costs of construction.
- To ensure successful passive design, it is best to imagine the home will have no power. Understand the sun, wind and light of the site.
- For participation with residents to be effective, it is vital to involve them at the earliest possible stage (design brief) and to use design teams who have the willingness and necessary skills to work well with residents.
- Team work is vital to overcome technical as well as non-technical resistance to change.
- Residents when given more choice are generally only interested in aspects which provide an immediate payback; this can be addressed through discussion and training on wider environmental issues.
- Unseen or unfashionable material or methods require more effort in convincing occupants of uptake or acceptance.

- Locally sourced, traditional materials and methods (hopefully not unfashionable) are often inherently environmentally, financially, and culturally sustainable and lend themselves to further financial and social sustainability by allowing the local residents to learn to build with local materials. Involving locals in the design and construction of their own community enables them to promote sustainable materials and methods and apply their new skills elsewhere, adding workforce to the new green jobs market.
- A holistic approach, e.g. area clean up, local food production involvement, sanitation improvement, creating less dependency on city provided resources and occupant involvement in all stages creates greater 'buy in' and pride in a newly created green social housing place. This is most successfully demonstrated through the Cato Manor Green Street project in South Africa.

Construction

- Demonstration or mock-ups of housing units can be helpful in convincing residents to accept new ideas and in assisting builders in understanding new construction methods or working with new materials
- Involvement of the future occupants in the planning and building process has been shown to be crucial in the success of a number of projects: Involvement gives occupants the sense of ownership, provides skills and ensures a level of understanding in what they will be receiving.
- Low-tech solutions ease self-help and mutual help in the building process and encourage transfer to future local projects.
- Collaborative teams are hard to manage - give each member of the team a voice, and something they can directly impact.

Handover, performance and beyond

- If occupants are not intimately involved in the planning and construction of the homes they will at least need to be trained one-on-one to understand any strategies or technologies that may be unfamiliar. In addition manuals or guidance notes are suggested. Never handover a building, especially with new technologies, without ensuring that occupants are comfortable with the new home. Handover can require multiple visits to guarantee smooth operation and satisfaction.
- An occupancy review is essential in order to assess the operation of the building post-occupancy and to understand how the building performs compared to expectations.
- A high-performance envelope (a lot of insulation with durable finishes) is money well spent.
- Important lessons are always learned from evaluating the performance of the building and listening to occupant's experience.
- As with public leadership programs (support, information and voluntary action), the evaluation, dissemination and advertising of success and methods in green social housing projects can result in successful policy changes locally. Refer to the example of the passivhaus development in Ljubljana where following the success of the project, local legislation requires that all new private and public building be designed to a low energy standard and incorporate renewable energy sources. Specifically in Slovenia, the transfer of ideas were

carried out through exhibitions, guided tours, presentations, workshops, the development of an educational programme for social housing companies and a practical guidebook for social housing companies on energy intelligent retrofitting.

Causes for failure of some sustainable social housing projects

Why social housing projects fail, lessons learned from Haiti (Vazquez, 2014):

- **Cost of living:** People living in slums do not have energy or water bills and are not accustomed to paying for these amenities. Even when the new housing may be provided for free, utility services such as electricity, gas, water or waste disposal can create financial problems for the occupants if they are not considered appropriately.
- **Location:** Social housing projects fail when they are built too far from town without regular and affordable transportation links. Social housing occupants must have easy access to social facilities, such as schools, health clinics, and economic centres.
- **Suitability:** Inappropriate design for climate or cultural expression can cause failure. Local understanding is essential for the design of social housing.
- **Role of the government:** The government can fail the social housing recipients by not asking about and not listening to the needs of the future occupants. Typically governments provide solutions that do not work, the government does not understand why the citizens will not live in the housing provided and the citizens think the government is the opponent, forcing then to live in houses that are not suited to their needs.
- **Multi-stakeholder approach:** Failure can occur by not involving local stakeholders in the process. Stakeholders such as, those in the private sector, NGOs and the recipients members, all have something to contribute to the longevity and success of a project.

Performance gap in four low carbon housing developments in England, UK

UK is legally obligated to meet an 80% carbon reduction by 2050, in the domestic sector; this means all new housing must be zero carbon from 2016. Since 2006 the Government has set ambitious targets for incremental changes to building regulatory standards by the implementation of sustainable design principles and micro-generation technologies.

In contrast to a green housing development in a developing country where a significant achievement is reached by countering misplaced ‘modern’ or synthetic methods of construction through local methods and materials and increased insulation, social housing in developed countries must reduce energy consumption from high levels where these modern methods are the convention. Where there is more energy consumption that must be reduced, there is often, in developed countries, more technology involved and therefore more expectations to deliver results. The UK Government’s Technology Strategy Board (TSB) has been funding the building performance evaluations (BPE) studies of a number of low carbon social housing developments throughout the UK to evaluate the actual energy and environmental performance of the dwellings both from a technical and occupants' perspective. The physical characteristics and sustainability features of four selected case studies from the TSB - BPE programme are listed in table 5.3.

Causes for the performance gap: discrepancies in built performance

The fabric performance for each housing development was evaluated using a range of diagnostic field tests which include: a whole house heat loss test (co-heating test[1]), air permeability test[2] and infrared thermography[3].

The findings from the BPE projects showed that overall there is a gap between the regulatory design compliance calculations pertaining to predicted Heat Loss Coefficients (HLC) and the actual measured HLC. For Cases A, B and C this gap is relatively small compared to the homes in Case D. Case D had serious issues with detailing and higher U-values than designed. Figure 5.2 shows the predicted and measured Heat Loss Parameter (HLP) for each case study home and compared them to UK regulatory standards. The HLP is the HLC normalised against the area of the home so that the values can be comparable. All homes but Case C would have a HLC compliant with 2010 Building Regulations (baseline standard for all homes) and only Case B would achieve CSH Level 6.

Air permeability tests revealed a noteworthy gap between designed and actual air tightness in the homes. The greatest concern is in Case D, where both homes missed the target by a large amount, especially Case D.2 with air permeability over twice as high as expected (figure 5.3). Case B, however, performed exceptionally. The results achieved by Case B undoubtedly benefited from the extensive modification to the original design in response to concern for thermal bridges and air tightness during prototyping and design review. In Cases A, C and D, better air tightness would have resulted from a higher quality of detailing at key junctions, skirtings and service penetrations (figure 5.4). Specifically, for Case D air leakage was found in a number of places: through penetrations in ground floor bathrooms, electrical cupboard, solar and MVHR cupboards, below skirting boards and around external doors on the ground floor. All cases would have benefited from more detailed care around door and window thresholds and seals and service penetrations. The roof gables also proved to be weak points for some homes. Air permeability test failures can result in delayed handover, time and payment disputes and costly remedial works. Some air leakage pathways are extremely difficult and expensive to fix.

1 *Co-heating testing is a post-completion test that is designed to quantify as-built whole building heat loss in a completed unoccupied house. The heat loss is sub-categorised by fabric (including thermal bridging) and ventilation heat loss measured as the Heat Loss Coefficient (HLC) (W/K).*

2 *Air permeability tests or blower door tests are performed before and after the co-heating test to help establish the air permeability and the heat loss due to air infiltration and exfiltration through the building fabric alone. Ventilation routes such as mechanical ventilation heat recovery (MVHR) units are sealed during the tests.*

3 *Infrared thermography visually renders thermal radiation from building elements helping locate heat related construction faults and leakage.*

TABLE 5.3 OVERVIEW OF CASE STUDY CHARACTERISTICS AND SPECIFICATIONS

	Case study A	Case study B	Case study C	Case study D
Developer	Small private developer	Volume House builder	Volume House builder	Social housing / Local authority
Process	Joint venture between landowners and sustainable developer Sold to occupants	Collaboration between volume house builder UK Government funded Carbon Challenge Programme	Design for Manufacture competition aimed at sustainable, efficient and cost effective developments	Low energy, social housing development funded by local authority
No. of bedrooms, house type	three bed, mid-terrace	two bed, semi-detached	three bed, end-terrace	three bed, end / mid-terrace
Construction type	timber frame const ruction	Structural Insulated Panels (SIP)	Structural Insulated Panels (SIP)	a timber frame and cast hempcrete
No. of case study houses studied	1	1	1	2
Target design rating	CSH[1] Level 5	CSH Level 6	EcoHomes Excellent	CSH Level 6
Main construction elements (as designed) U-values W/m²K	• Walls: Rendered / wood clad timber frame, U-value: 0.16 • Roof: Pantile on timber, U-value: 0.14 • Ground floor: Sealed timber floor, U-value: 0.15 • Windows: Wood frame, triple glazing, U-value: 0.9	• Walls: Rendered SIPs, U-value: 0.12 • Roof: SIPS, U-value: 0.12 • Ground floor: Screed over insulation on beam and block, U-value: 0.19 • Windows: Wood frame, triple / double glazing mix, U-value: 0.9/ 1.4	• Walls: Brick, rendered block, cedar cladding on SIPs, U-value: 0.21 • Roof: Concrete/clay tiles on SIPs panels, U-value: 0.23 • Ground floor: Screed over insulation on beam and block, U-value: 0.2 • Windows: Wood frame, double glazing, U-value: 1.4	• Walls: Rendered hempcrete cast into timber frame, U-value: 0.18 • Roof: Tile on timber, U-value: 0.15 • Ground floor: Screed over insulation on beam and block, U-value: 0.12 • Windows: PVC, double glazing, U-value: 1.3/1.8
Space heating and hot water system	Wood pellet burner with radiators and solar collectors and 300 litre thermal store	Communal gas CHP (hot water distributed through underground district heating network)	Gas boiler with conventional radiators	Exhaust Air Heat Pump (EAHP); under floor heating coils and 4m² vacuum tube heat pipe solar collectors
Target Air tightness ($m^3/h/m^2$ @50Pa)	5	1	5	2
Ventilation strategy	MEV	Mechanical ventilation with heat recovery (MVHR)	Mechanical ventilation with heat recovery (MVHR)	Mechanical extract ventilation (MEV) through Exhaust Air Heat Pump (EAHP)
Renewables	2 kWpk Photovoltaic	-	-	4 kWpk Photovoltaics
Rainwater harvesting	2500 litre store/house	Common collector	-	-

FIGURE 5.2 HEAT LOSS PARAMETER FOR TESTED CASE STUDY HOMES COMPARED TO UK REGULATORY STANDARDS

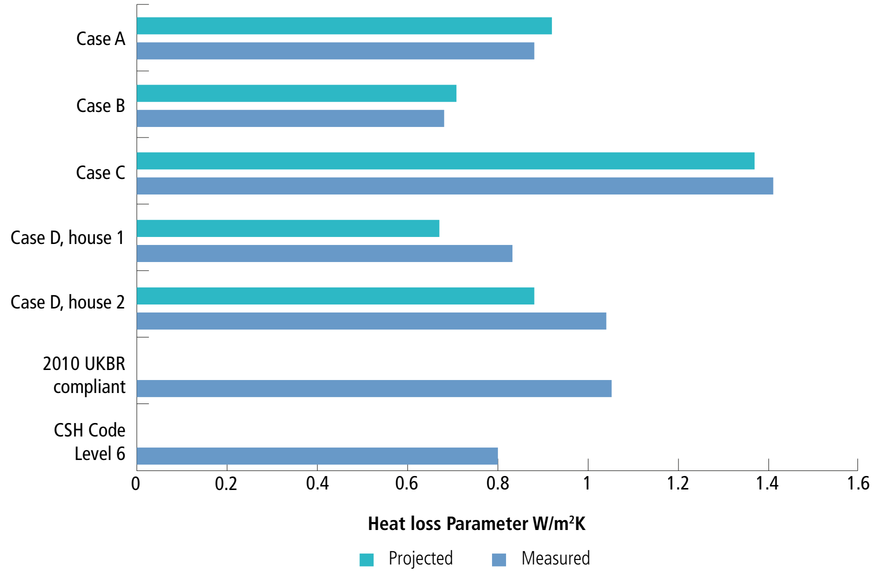


FIGURE 5.3 AIR PERMEABILITY FOR TESTED CASE STUDY HOMES COMPARED TO PRACTICE STANDARDS

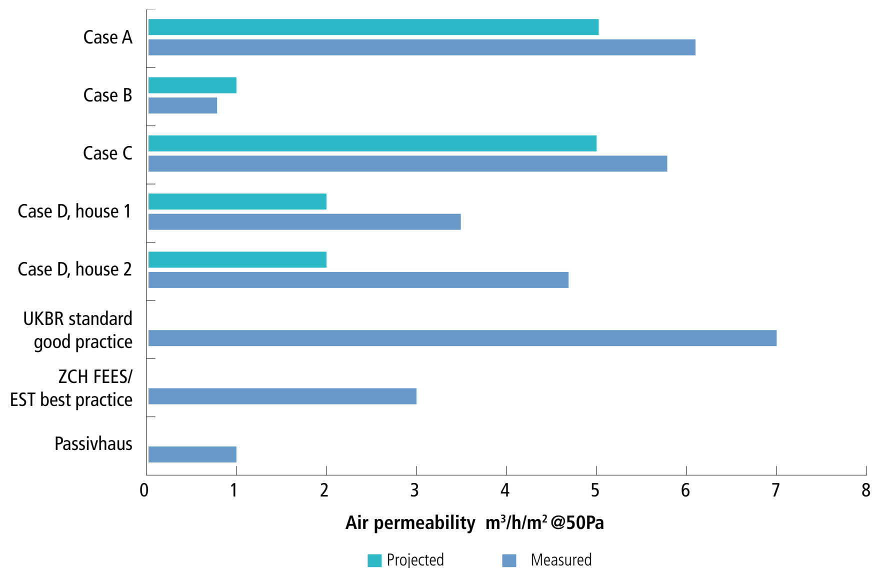
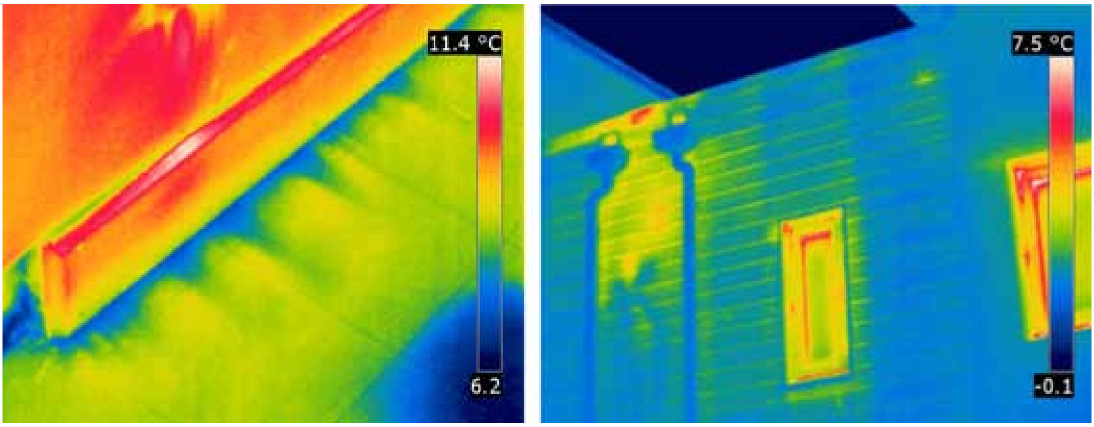


FIGURE 5.4 THERMOGRAPHIC IMAGES OF HEAT LOSS THROUGH THE FLOOR / WALL JUNCTION OF THE PARTY WALL IN CASE A (LEFT) AND HEAT LOSS THROUGH THE PARAPET JUNCTION OF THE PARTY WALL IN CASE C (RIGHT).



Note: *the left image shows unfinished skirting board along the floor.*

Table 5.4 details a list of other issues leading to the performance gap found through building performance evaluation

TABLE 5.4 EXAMPLES OF FINDINGS FROM BPE REGARDING SPECIFIC AREAS OF EVALUATION

	Case A	Case B	Case C	Case D
Systems installation and commissioning	Commissioning failure: MEV was found to be delivering inadequate air flow rates (below regulations)	MVHR found to have an imbalance between supply and extract of up to 30%	Ventilation flow rates are lower than recommended due to flexible ductwork and commissioning was incorrectly performed.	Heating controls and zone thermostats not connected, incorrectly installed (first floor heating inoperable)
Design and installation of control interfaces	No control for changing ventilation rates.	MVHR controls unclear and difficult to operate; little indication of system response	Location of MVHR boost switch inaccessible and non-compliant with Building Regulations	Two conflicting control approaches for the house: masterstat and room thermostat
Handover to occupants	Lack of feedback in all stages; one sided handover (no interaction with occupants)	Responsibility for the handover was not defined. The developer expected individual suppliers to carry out handovers of their systems.	Explanations of the MVHR, ventilation and heating controls contained errors and did not demonstrate maintenance procedures e.g. filter replacement	Home user guide would have benefited from more clarity simplicity and diagrams (apart from this, Case D was relatively successful in handover)

	Case A	Case B	Case C	Case D
Occupant survey and interviews	Occupants feel they have little control over heating and ventilation, poor access to controls	N/A	Poor thermal comfort: too hot in summer and cold in winter, dry in both seasons; All occupants report overheating in summer	Poor acoustic performance of party walls; Privacy conflict with full height windows in bedrooms; High ceilings caused problems for cleaning and operation of roof lights.

Note: *this table is not exhaustive*

The evidence for the performance gap gathered across a variety of built forms and modern construction systems show that while certain discrepancies may have begun due to a particular briefing, construction, specification or design error, the extent of the resultant performance gap is either amplified or alleviated by the effectiveness of the troubleshooting response from the design team, construction team or developer. A common theme between all case study developments is the difficulty caused by post-design, mid-construction changes to the homes. These changes can be a result of initial miscommunication in the design and planning phase, last minute client misgivings or a design compromise in response to limited knowledge of subcontractors et al. Table 5.5 lists some common causes behind performance gap which were shared between most cases and are notable causes for the performance gap. As of early 2014 the owners of case study D (the local authority) is in the process of removing the EAHP (the heating system) from the homes due to difficulty with the systems operation, maintenance and delivery of expected results.

TABLE 5.5 COMMON EMERGING ISSUES BETWEEN CASE STUDY DEVELOPMENTS

	Case A	Case B	Case C	Case D
Construction faults as a result of post-design changes	✓	✓	✓	
Inadequate or poorly detailed insulation and air tightness at junctions	✓		✓	✓
Greater heat loss through party walls than predicted	✓	✓	✓	N/A
Inadequate installation and commissioning of systems	✓	✓	✓	✓
Controls not accessible, non-ergonomic or difficult to understand	✓	✓	✓	✓
Occupant dissatisfaction with provision for storage	✓	N/A	✓	✓

***Note:** N/A indicates that the issue was not measured or data was inconclusive. Though occupant dissatisfaction with storage space is not directly linked to the overall carbon emissions of a building it is a recurring theme in developments. Indirect problems may occur as in Case C, the MVHR cupboard is doubling as storage space and being overwhelmed with occupant belongings, limiting access to the unit.*

Much of the issues listed above are the result of communication drawbacks. These are a result of weaknesses in drawn communication of intention, communication of expectations (e.g. is the construction team capable of working with a specified material or installing equipment), onsite evaluation of work done and communication of expectation for improvement. To evaluate the work in progress and to ensure coordination and met expectations, it is vital that project teams stay engaged after practical completion to hand-hold clients (occupants) during the initial period of occupation, and to stay involved for up to three years providing professional aftercare, and for documenting the lessons learned for future development (Gupta et al., 2013).

CHAPTER

06

Conclusions and recommendations

The provision of 'affordable' (social or public housing) homes is an issue of profound international importance. Solutions must be found to address the crisis of affordable housing which also acknowledges the parallel crisis of climate change. Sustainable urbanization therefore needs affordable, adequate and green housing in order to respond to the global rapid population growth especially in the low-income housing areas of countries. Responses to this problem have to be holistic, multi-level and interdisciplinary, and must acknowledge local cultural, economic, legislative and environmental factors (UN-Habitat, 2012a).

Overall work on green building is progressing in developing countries. However barriers to increasing the take-up of green social housing exist in both developing and developed nations. Some common barriers to effective implementation of green social housing include: perception of capital cost versus unfamiliarity with life-cycle costs and life-cycle performance, tendency to develop standard regional and national solutions - without localised focus, incongruent economic interests. Policy driven demand for green buildings has the potential to open up the market for green jobs and skill sets in the short term (fiscal stimulus) and create new markets in the long term. The construction sector, as a key enabler of economic growth, has a large impact on the labour market. Green growth is likely to create new green jobs, reduce 'brown' sector jobs and lead to a greening of existing jobs. Training and awareness initiatives will be key steps to this transition, providing an opportunity to engage with the informal sector and improve working conditions and inspection approaches (UNEP SBCI, 2009a).

Green housing design requires careful consideration of often overlooked design steps such as building orientation, thermal mass, shading and type of materials used. Material use can impact the environment before, during and after use of the material. Evaluation of the construction process and building performance in-use is essential to help shape future policies and practices; create evidence base for promoting green buildings and to help secure funding for exemplar projects. Impact evaluation can have varying complexities and focus on environmental, social, economic and cultural aspects, however the three key evaluation criteria recommended initially are – energy use, comfort and occupant feedback.

Every social housing project will be different and needs careful analysis, not only in respect of the site capacity but also in terms of future users of the buildings. Through case study analysis, it has overwhelmingly been proven to be essential to involve tenants in all discussions at every stage, in order to ensure that they have maximum information on how to best use and live in the dwellings and thus maximise their energy savings and future prospects.

6.1 Key messages and recommendations

Key recommendations for policy-makers

- The building sector, particularly social housing, provides the opportunity to explore green building practices and significantly reduce GHG emissions through cost-effective means while providing much needed housing in a healthy and sustainable manner.
- Local or national emission reduction targets cannot be met without supporting the energy efficiency and sustainable progress in the building sector.
- Failure to develop and build sustainably at both urban and building level will lock-in disadvantages of poorly performing (energy, personal wealth, health, comfort, etc.) buildings as energy costs increase and the climate changes.
- The following policy instruments have been rated highly in policy reviews (Urge-Vorsatz et al., 2007; UNEP, 2009) in both effectiveness to reduce GHG emissions and cost effectiveness to society:
    - economic incentives: tax exemptions/ reductions for sustainable building and practices;
    - support, information and voluntary action: public leadership programmes; and
    - regulatory and control mechanisms (e.g. more progressive building regulations).
- Combining regulations and incentives with measures to attract attention such as information or public leadership programs have the highest potential to reduce GHG emissions (Warren, 2007). Incentives are required to break the cost barrier and increase the acceptability and use of sustainable approaches to design and construction.
- Building regulations should be carefully assessed and reviewed periodically (including after research, testing and development) for barriers to green practices or material use.
    - Where regulations are in an advanced stage and incentives are also being used to increase green social housing growth, post-occupation evaluation and monitoring should also at least be incentivised, or at best be required. As an example, where sustainability certification is

awarded, it should be limited to homes that have had BPE/diagnostics demonstrating success (Gupta et al., 2013).

- Government support and leadership is essential for any significant sustainable change: Government will need to take a proactive role and provide adequate support through policy and technical means to local authorities when implementing programmes, supported by cooperating partners. In addition, government has the capacity and is encouraged to prototype or demonstrate green building practices and material use either through public or private buildings to create awareness and inspire the same in the private sector.

- There is a need for technical training of public officers and market actors to ensure understanding and capacity to implement sustainable technologies, as well as maintain these over the life of the building.
- For a sustainable approach to be successful, it is important to have a clear idea about habits, lifestyles and preferences of a society so as to define applicable solutions and realistic responses to actual needs.
- Do not assume that policies or concepts that benefit the general population will benefit indigenous peoples (UN-Habitat, 2011e).
- A sustainable approach should be a continuous and growing process to be able to fulfil all essential objectives; benefiting from previous success (UNEP, 2013).
- In growing urban locations, incentivise social housing development in areas of the city well served by transportation so that occupants can access work opportunities, schools, healthcare and other amenities.

Key recommendations for developers

- For a sustainable approach to be successful, it is important to have a clear idea about habits, lifestyles and preferences of future occupants so as to define applicable solutions and realistic responses to actual needs.
- Planning and implementation of sustainable developments are significantly more effective when the communities are involved from inception through all phases.
- Do not assume that design and planning concepts or needs that benefit the general population will benefit indigenous peoples (UN-Habitat, 2011e).
  - Life cycle analysis is helpful in quantifying the benefits of green buildings across the life span of the building. Always speak with investors about life cycle costs, not just the initial costs of construction.
  - If relocating a community, location in areas well served by transportation is important for access to potential work, schools, and healthcare.
  - Serious consideration for upgrades must be made when bringing occupants out of slums or conditions where they were not previously responsible for fuel, water or sewage bills.
- Involvement of the future occupants in the planning and building process has been shown to be crucial in the success of a number of projects: Involvement gives occupants the sense of ownership, provides skills and ensures a level of understanding in what they will be receiving.

- Developers need to share and seek experience. This is especially necessary for the smaller developers that may have less experience and more to lose.
- The developer should take the lead on initiating and ensuring communication between all stakeholders.
- If occupants are not intimately involved in the planning and construction of the homes they will at least need to be trained one-on-one to understand any strategies or technologies that may be unfamiliar. In addition manuals or guidance notes may be needed. In this case, create comprehensive and visually diagrammatic guidance for users by referencing best practice guidance and handover processes.
- For large multi-project developers, an occupancy review is essential in order to assess the operation of the building post-occupancy and to understand how the building performs compared to expectations.
  - Important lessons are always learned from evaluating the performance of the building and listening to occupant's experience.
  - Monitoring and evaluation of performance of green buildings in practice and reporting and verification of green building performance, serves as an effective tool in providing confidence in the outcome and benefits of green buildings. This, in turn, can be used to influence policy-makers to further incentivise green social housing (Gupta et al. 2013).

Designers and built environment professionals

  - Life cycle analysis is helpful in quantifying the benefits of green buildings across the life span of the building. Always speak with clients or investors about life cycle costs, not just the initial costs of construction.
  - Keep the design simple but adaptable and flexible; test the designs on various sites to ensure they can respond to differing site contexts.
  - To ensure successful passive design, it is best to imagine the home will have no power.
- Unseen or unfashionable material or methods require more effort in convincing occupants of uptake or acceptance: demonstration or mock-ups of housing units can be helpful in convincing residents to accept new ideas and in assisting builders in understanding new construction methods or working with new materials
  - Involvement of the future occupants in the planning and building process has been shown to be crucial in the success of a number of projects: Involvement gives occupants the sense of ownership, provides skills and ensures a level of understanding in what they will be receiving.
  - Low-tech solutions ease self-help and mutual help in the building process and encourage transfer to future local projects.
  - Collaborative teams are hard to manage - give each member of the team a voice, and something they can directly impact.

  - Communication and involvement of all parties involved in the design and construction process (including client and suppliers) through all stages is highly beneficial in delivering green and cost effective results.

Green social housing occupants or future occupants

- Demand green social housing from policy-makers and developers when informed that new-build or retrofit will take place in your community or for your community.
- Ask to be involved in the process. There are a number of benefits such as:
  - influence over briefing, design and location decisions,
  - you can bring concepts or needs to light of which developers and designers may not be aware,
  - reduction in construction costs as a result of active participation and building
  - skill development; future placement in green jobs market
- When confused about how to maximise use of new green home or concerned about unexpected costs (fuel water bills, etc.), it is vital to communicate the issues faced as there may be under-performance issues which need to be brought to the attention of the developer, designers, builders, etc.

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Appendix A: Checklist for policy makers

Social housing provision must be (re)developed to achieve multiple benefits across the four sustainability dimensions – to simultaneously improve people's livelihoods, contribute to the economy, and enhance the environment. A crucial aspect is sustainable policy delivery. This relies on a strategic vision and supportive institutions, multi-stakeholder cooperation, and sustainable sources of funding – all underpinned by appropriate regulation and capacity building (UN-Habitat, 2012c).

Policymakers can use the following questions as a checklist to review their programmes and policies with regard to the provision of affordable, accessible and sustainable housing (UN-Habitat, 2012a; UN-Habitat, 2012c; UNEP, 2013):

- What are the Sustainability priorities / commitments at the National level?
- Does housing policy aim to deal with poverty reduction, socio-economic development and climate change simultaneously?
- Is there a special organisation charged with the responsibility of coordinating sustainable affordable housing initiatives?
- Is the development of sustainable housing institutionalised as a long-term sustainable policy and not dependent on change in government?
- Is there a clear housing vision for the country over a 10-20 year timeframe and key strategic objectives?
- How are the Sustainability priorities / commitments at the local / city level different, perhaps more progressive than national level?
- Are there incentives in place to encourage builders / developers to go beyond the baseline requirements of the building regulations?
- What are the Sustainability priorities / environmental risks at the local / city level?
- What are the main social challenges for social housing users at a local / city level?
- Do building codes enable the use of traditional materials and sustainable construction techniques which may reduce embodied energy, enable incremental self-help housing and have the capacity to increase social, cultural sustainability?
- Is there wide and open consultation with multiple stakeholders regarding the development of sustainable housing strategies and projects?
- Is there local and end-user participation to learn about and integrate local knowledge, challenges, culture and traditions?
- Are there educational programmes for green building skill development?
- Are monitoring and evaluation encouraged, and if so, are the findings being used to quantify and / or market the benefits of sustainable social housing?
- Is there support for campaigns and promotions to present alternative ways of building and to spread the knowledge of sustainable housing practices?

- Is there a practice of consulting with the local community at the design stage to take their needs, ideas and preferences into account through such methods as public meetings?
- Is there follow up in social housing development, e.g. carry out a social impact assessment to study the effects of the project on the existing community?
- Does social housing policy ensure project contribution to the economic and social welfare of the community?
- Does social housing policy ensure security and crime prevention through community involvement and design principles?
- Does social housing policy encourage (e.g. through incentives) the use of previously developed sites or sites within urban boundaries (thereby reducing green field development and providing access to economic and social activity)?
- Does social housing policy encourage the reuse of existing buildings?
- Does social housing policy promote a compact, mixed use neighbourhood and consideration for the appropriate density for each project location?
- Does social housing policy encourage alternative access / transportation support, e.g. cycle ways and pedestrian access?
- Does social housing policy protect and conserve existing ecological features including soil, vegetation, and natural habitats?
- Does social housing policy encourage minimising rainwater runoff, e.g. through avoiding / limiting hard external landscaping?
- Does social housing policy encourage the use of locally sourced, sustainable materials?
- Does social housing policy encourage the use of renewable materials from verifiable sources?
- Does social housing policy encourage the use of renewable energy sources (e.g. wind, solar, hydro, photovoltaic bank, CHP operating on biomass or waste) to decrease need for fossil fuels generating CO_2 emissions?
- Does social housing policy encourage the reduction of water requirement in houses by using efficient fixtures like low-flow fixtures, etc?
- Does social housing policy encourage harvesting of rainwater and grey water for use on site?

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Promoting Policies and Practices for Sustainability

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