

II. REVIEW OF LITERATURE

The literature pertaining to the study on “**Adaptive Reuse and Refurbishment as Prospects for Sustainability in Buildings**” is reviewed under the following headings:

A. Phenomenon of Carbon Footprint

B. Environmental Impact of Construction Projects

C. Concepts of Obsolescence, Adaptive Reuse and Refurbishment

D. Green Technology and Sustainability

E. Rating Systems for New and Existing Buildings in India

A. Phenomenon of Carbon Footprint

Carbon footprint is a very powerful tool to understand the impact of personal behaviour on global warming. It can be calculated for a product, service, person or even a country.

The Carbon Trust (2007) defines carbon footprint as a (Figure 1) methodology to estimate the total emission of greenhouse gases (GHG) in carbon equivalents from a product across its life cycle from the production of raw materials used in its manufacture, to disposal of the finished product (Pertsova, 2007). A running car, a heating house and other processes that produce food and goods, use oil, gas or coal and all these activities emit certain quantities of CO₂ into the atmosphere.

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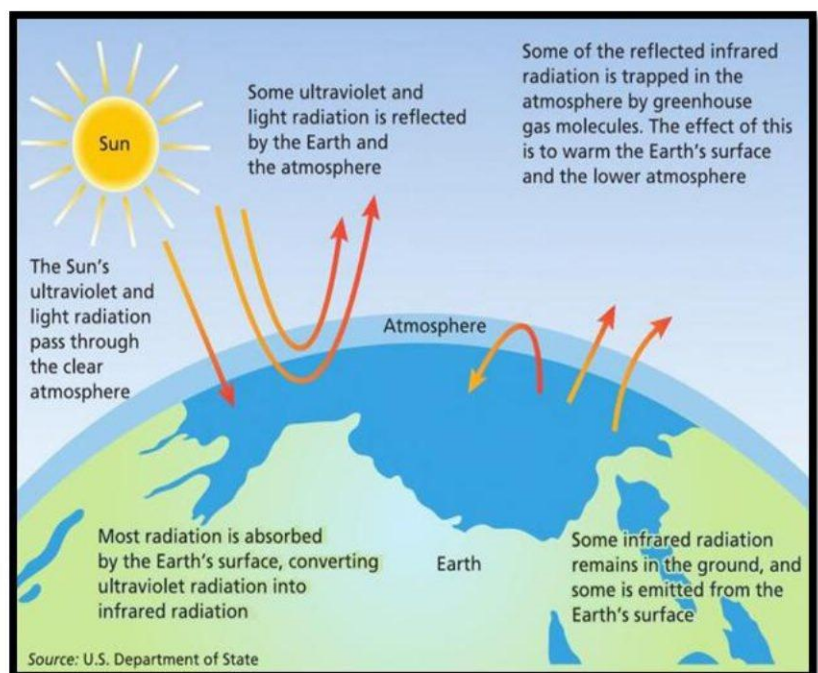
Technology (POST 2006) defines ‘Carbon Footprint’ as the total amount of CO₂ and other greenhouse gases, emitted over the full life cycle of a process or product, which accounts for the different global warming effects of other greenhouse gases. Philander (2008) states that carbon footprint is not only a method of estimating the amount of CO₂ and greenhouse gases humans are producing but a way to understand the chemical nature



these substances have in different parts of the atmosphere. They are responsible for the greenhouse effect.

Global warming and climate change refer to an increase in average global temperatures. Natural events and human activities are believed to be contributing to an increase in average global temperatures. This is caused primarily by increases in “greenhouse” gases such as Carbon di oxide (CO_2). The term greenhouse is used in conjunction with the phenomenon known as the greenhouse effect. Gaan (2008) elucidates the phenomenon as follows:

- *Energy from the sun drives the earth's weather and climate, and heats the earth's surface*
- *The earth, in turn radiates energy back into space*
- *Some atmospheric gases (water vapor, CO_2 , and other gases) trap some of the outgoing energy, retaining heat somewhat like the glass panels of a greenhouse*
- *These gases are therefore known as greenhouse gases*
- *The greenhouse effect is the rise in temperature on Earth as certain gases in the atmosphere trap energy.*



Many of these greenhouse gases are actually life-enabling, for without them, heat would escape back into space and the Earth's average temperature would be a lot colder. However, if the greenhouse effect becomes stronger, then more heat gets trapped than needed, and the Earth might become less habitable for humans, plants and animals (IBON, 2008). ***What are these Greenhouse Gases (GHG)?***

Since the Industrial Revolution began around 1750, human activities have contributed substantially to climate change by adding CO_2 and other heat-trapping gases to the atmosphere. These GHG emissions have increased the greenhouse effect and caused Earth's surface temperature to rise. The most important GHGs directly emitted by

humans include, CH₄, nitrous oxide (N₂O), and several others. The sources of these gases (Verheyen, 2005) are detailed in Exhibit (1).

Greenhouse Gases	Natural Source(s)	Human Source(s)
Carbon dioxide - CO₂ <i>(Lallanilla, 2010)</i>	<ul style="list-style-type: none"> - Absorbed and emitted in the carbon cycle - Animal and plant respiration - Volcanic eruptions - Ocean-atmosphere exchange 	<ul style="list-style-type: none"> - Burning of fossil fuels like oil, coal and gas - Changes in land use (deforestation)
Methane - CH₄ <i>(Lallanilla, 2010)</i>	<ul style="list-style-type: none"> - Natural wetlands - Agricultural activities 	<ul style="list-style-type: none"> - Fossil fuel extraction - Transport
Nitrous oxide - N₂O <i>(National Geographic)</i>	<ul style="list-style-type: none"> - Released from landfills - Agricultural activities - Natural biological processes 	<ul style="list-style-type: none"> - Fuel burning - Gases used for refrigeration and industrial processes
Water vapour <i>(NCEI)</i>	<ul style="list-style-type: none"> - Most abundant atmospheric greenhouse gas - Largely controlled by local temperatures. 	<ul style="list-style-type: none"> - As planetary warming due to human sources increases, water vapor concentration increases and adds to the warming effect.
Tropospheric ozone - O₃ <i>(National Centers for Environmental Information (NCEI))</i>	<ul style="list-style-type: none"> - Ultraviolet radiation and oxygen interact to form ozone in the atmosphere. - Existing in a broad band, commonly called the ‘ozone layer’, a small fraction of this ozone naturally descends to the surface of the earth. 	<ul style="list-style-type: none"> - Emissions from chemical reactions of nitrogen oxides and volatile organic compounds from automobiles, power plants, and other industrial and commercial sources in the presence of sunlight.
Fluorinated gases (‘F- gases’) Chlorofluorocarbons (CFCs), Hydro chlorofluorocarbons (HCFCs), Hydro fluorocarbons (HFCs), Per fluorocarbons (PFCs), and Sulfur hexafluoride (SF₆) <i>(NCEI)</i>	<ul style="list-style-type: none"> - Chlorofluorocarbons (CFCs) have no natural source 	<ul style="list-style-type: none"> - Coolants - Foaming agents - Fire extinguishers - Solvents - Pesticides - Aerosol propellants
<i>Exhibit 1 – Sources of Greenhouse gases</i>		

B. Environmental Impact of Construction Projects

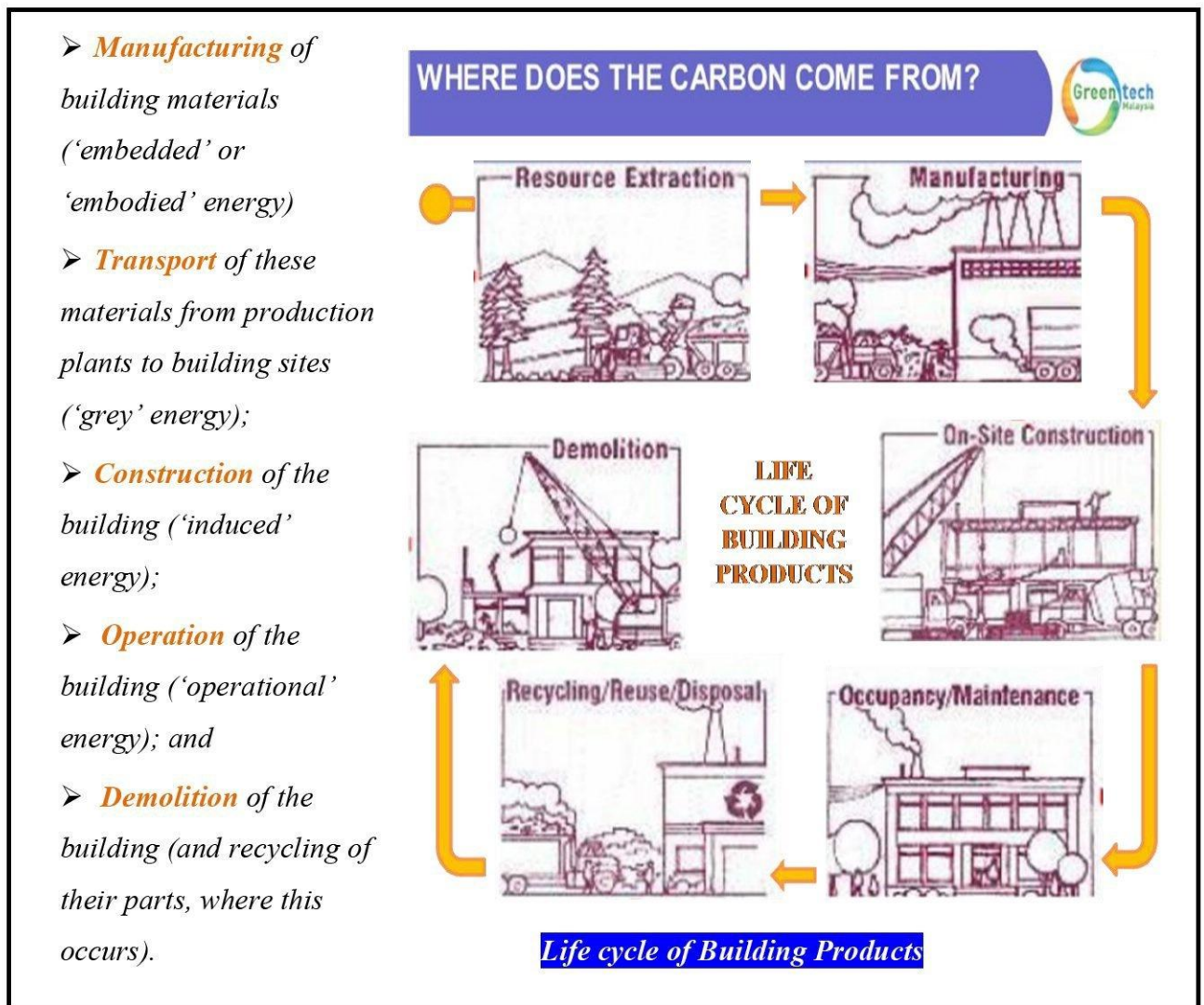
The impact of the construction industry on the environment is substantial. During the extraction and manufacture of construction materials, their transportation, the process of construction and the use of buildings, large quantities of energy are used. Major contributions are made to the overall production of carbon dioxide which exacerbates the 'greenhouse' effect. The environmental impact is global but, during the construction process, communities and individuals are affected (Ashworth and Perera, 2013).

Today, buildings are responsible for more than 40 per cent of global energy used, and as much as one third of global GHG emissions, both in developed and developing countries. The building materials industry is relatively energy-intensive, second only to iron and steel (Ashworth, 2013). About one third of global final energy use is for provision of energy services in residential, commercial, and public-service buildings (Liu et al., 2010).

1. Assessing Emissions through a Life Cycle Approach: GHG emissions from buildings primarily arise from their consumption of fossil-fuel based energy, both through their direct use and through the use of electricity generated from them. Significant emissions are also generated through construction materials, in particular insulation materials, and refrigeration and cooling systems (Torgal et al., 2013).

People using buildings, constructing and refurbishing buildings and commuting to and from buildings consume energy. Nearly all come from the combustion of fossil fuels, which release greenhouse gases into the atmosphere (Clark, 2013). It is quantified using kilograms of carbon dioxide equivalent (kgCO_2e)¹ which allows different forms of energy consumption – electrical, heat, embodied and motive (transport) - to be compared using a single metric. Scientists predict that left unchecked, emissions of CO_2 and other greenhouse gases from human activities will raise global temperatures by 2.5°F to 10°F . The effects will be profound, and to address the threat of climate change, greenhouse gas emissions must be slowed, stopped, and reversed. Meeting the challenge will require dramatic advances in technologies and a shift in how the world economy generates and uses energy (Hayek, 2007). Construction project proposals hence should initiate consideration of these factors too.

Graham (2003) uses a Life Cycle Approach to link emissions to the different stages of a building's life. It is illustrated in the Box given below.



C. Concepts of Obsolescence, Adaptive Reuse and Refurbishment

1. Obsolescence: When buildings are carefully designed, constructed and maintained, their physical life spans can be almost indefinite (Ashworth, 2013). A building's performance will decline as the condition of its structure and fabric deteriorates; the physical life however can be extended with maintenance and refurbishment activities. Even when building remains in good condition, its service life is reduced due to various expectations. The service life refers to the period of time over which a building functions above a minimum acceptable level of performance (Iselin and Lemer, 1993). Hence,

Finch (2011) describes the reduction in the building's service life due to rise in expectation as 'obsolescence'. Thomsen and Flier (2011) affirm that the characteristics and symptoms of obsolescence are explored specifically to address how buildings can be diagnosed and when and to what extent is demolition an unavoidable consequence.

The Merriam-Webster dictionary (2009) defines 'obsolescence' as the phase of growing old or becoming disused. According to Nutt et al (1976), the buildings can truly be defined as 'obsolete', only when they have become completely useless with respect to all possible uses that they have been called upon to support. Utility – the sense of usefulness, desirability or satisfaction – is therefore central to the concept of obsolescence; if something is not felt to be providing utility, it will be considered obsolete (Smith et. al.1998).

The concept of 'obsolescence', of course an age old concept, is an essential consideration during the assessment of value (Reed 2007). Various studies, therefore categorize obsolescence to fall under different types like *physical, functional, locational, environmental, economic, aesthetic, legal, social, technological* and *historical*. Exhibit (2) gives an over view of the types of obsolescence.

It is difficult to identify and accurately measure every form of obsolescence that affects property since each type of obsolescence affects different properties to varying degrees; furthermore each type may have commenced at a different time (Reed et al. 2008). At times there is substantial overlap between each type of obsolescence and this area is relatively 'grey'. Obsolescence may affect the land and/or building component in varying degrees, as well as commencing at different times and affecting the highest and best use (Lipscomb 2002). Whilst it has been acknowledged that various types of obsolescence exist and at varying degrees, there is little dispute that the profile of sustainability has increased recently and is a factor in many property decisions. Arguably it is not possible to make a property-related decision without some consideration about sustainability. Probably efforts on adaptive reuse and refurbishment can prove beneficial.

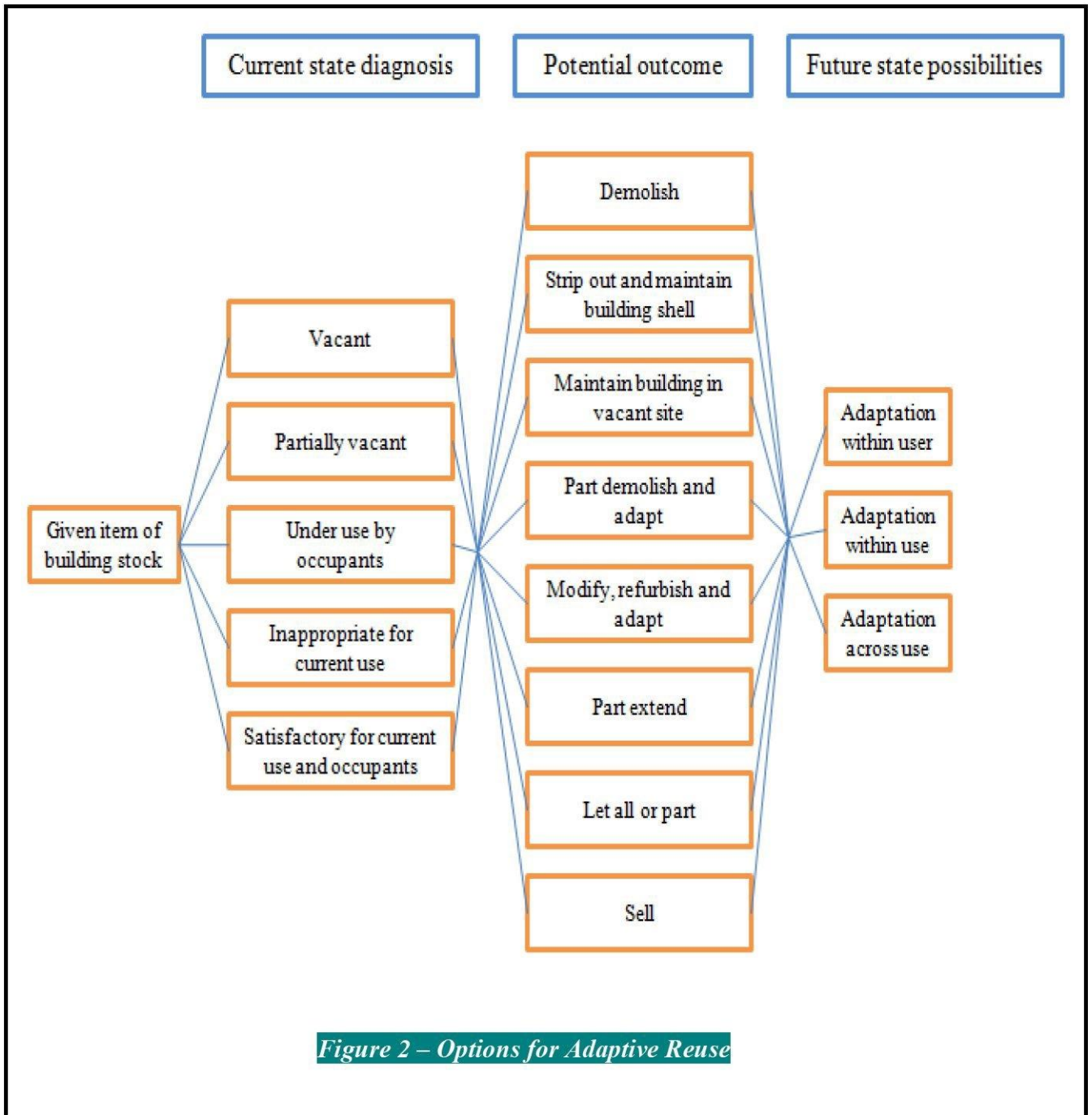
Type of Obsolescence	Elucidation
Physical Obsolescence <i>Kirwan and Martin (1972)</i>	It is the deterioration of the physical structure of the building, a combination of age, use and scale of maintenance.
Functional Obsolescence <i>Rand (1986) and Baum (1991)</i>	It is a product of defective layout and technological progress that results either in change in the occupiers' requirements or in the introduction of new building products.
Economic Obsolescence <i>Salway (1986)</i>	It is the result of a change in the "highest and best use" for the land. It is a function of appreciation rather than depreciation: a building becomes economically obsolete not as a result of the existing structure, but through enhancement of the development potential of the underlying land.
Aesthetic Obsolescence <i>Kohler et al. (2010)</i>	It results when a building is no longer in accord with the taste of an epoch. The effect of aesthetic obsolescence is greater in commercial buildings because the buildings with new architectural styles can fetch higher rental values.
Environmental Obsolescence <i>Medhurst (1969)</i>	It results when changes in the character of an area may make a building unsuitable for its original intended use. Environmental obsolescence will normally be of greater relevance to depreciation of land than to the depreciation of buildings.
Legal Obsolescence <i>Remoy (2010)</i>	Legal obsolescence stems from the introduction of new legislation or new standards controlling matters such as health, safety, and fire control, which in extreme cases may render a building obsolete.
Social Obsolescence <i>Calus (1986) and Baum (1989)</i>	Changes in social needs might result in occupiers demanding for high and compatible image, good neighborhood and amenities. Many building become socially obsolete although suitable for the purpose envisaged, because it is situated in the wrong location and therefore of only limited practical to use.
Technological Obsolescence <i>Calus (1986)</i>	This form of obsolescence occurs as a result of technological innovation, when the building is no longer technologically superior to alternatives and replacement is undertaken because of lower operating costs or greater efficiency
Locational Obsolescence <i>Bryson (1997)</i>	A building can become locationally obsolete when the property suffers from devaluation due to change in the economic activities in the area. A change in the city planning, such as relocation of commercial areas, construction of new roads and motorways can change the economic activities of the affected areas.
Historical Obsolescence <i>API (2007)</i>	Historical obsolescence may occur if a property is deemed to be heritage listed with associated development restrictions
<i>Exhibit 2 - Types of Obsolescence</i>	

2. Concept of Adaptive Reuse: Adaptation is derived from the Latin ‘ad’ (to) ‘aptare’ (fit). Douglas (2002) asserts adaptation, as the process of adjustment and alteration of a structure or building and / or its environment to fit or suit new conditions; it is also considered as work accommodating change in use or size or performance of a building which may include alterations, extensions, improvements, and other works modifying it in some way. The adaptability of any building depends on its design, form, materials, and the extent to which a building is appropriate for its purpose. The building’s capacity for adaptability is usually affected by its structural design, the different services within, its finishes, the internal layout, and its external appearance.

Burchell and Listokin (1981) define ‘**adaptive reuse**’ as a revitalization strategy which employs a series of linked procedures to plan for, acquire, manage and reuse surplus or abandoned real estate. It is a process that retains as much as possible of the original building while upgrading the performance to suit modern standards and changing user requirements (Latham, 2000) and the rehabilitation or renovation of existing buildings or structures for any uses other than the present (Mofidi et al., 2008). The various options for adaptive reuse of buildings as illustrated by Wilkinson et al., (2014) are given in Figure 2.

Changing conditions leave a constant supply of buildings and structures available for reuse and can be considered based on three levels:

- ***Adaptability within user** – the extent of which a building can adapt to support the needs of the existing users with minor and infrequent modifications or renovations*
- ***Adaptability within use** – the ease with which the building can adapt to the needs of different occupiers from the same user group without major refurbishment or upgrading*
- ***Adaptability across use** – the flexibility of the building to adjust to a whole new function and adapt to the requirements of a new use type, for example a switch from a commercial type to a residential type*



Adaptive reuse can be applicable to any type of existing building, from industrial buildings to churches and anything in between, with a resultant use that they can vary just as much. Vanegas et al., (1995), Ball (2002), Douglas (2002) , Holyoake and Watt (2002), Bullen (2007) and Langston et al., (2007) summarize the virtues and shortcomings of adaptive reuse in Table 1.

Table 1: Advantages and Disadvantages of Adaptive Reuse

Advantages	Disadvantages
<ul style="list-style-type: none"> ▪ Energy Conservation by reclaiming and repurposing existing structures and their embodied energy. ▪ Contribution to Sustainability by lowering material, transport and energy consumption and pollution due to reuse ▪ Saves Time as the building and infrastructure is in place, municipal approval and permitting can occur more quickly in comparison to new construction. ▪ Cost Savings as many of the existing elements can be reused rather than incurring the expense of disposing, demolishing and rebuilding. ▪ Environmental Benefits as the reuse and recycling of the existing materials and structure reduces the amount of waste entering landfills ▪ Potential Tax Advantages can be availed by owners for federal tax credits for rehabilitation investments in historic buildings and other incentives. ▪ Increases Market Value by preserving aesthetically-appealing building and architectural features of the past which are often not economically possible to reproduce. ▪ Enhances Community Character by providing renewed life to historic structures and linking community's history, its present and future. ▪ Encourages Investment by development and revitalization in vacant and underused areas. 	<ul style="list-style-type: none"> ▪ Functional Restrictions as the layouts and heights may necessitate compromises and prevent full satisfaction of the users' needs. ▪ Technical difficulties as existing buildings contain some latent defects and deficiencies that may prove difficult to resolve. ▪ Economical disadvantage as it is often expensive and sometimes require substantial and costly refurbishment. Moreover, the energy costs may be higher in adapted buildings because it can be difficult to achieve modern insulation standards by retro-fitting. ▪ Environmental: Not all adapted buildings result in an improved internal or external environment. ▪ Legal: Full code compliance with the building regulations may be difficult to achieve in some older properties. Constructional and spatial constraints can inhibit the attainment of the required means of escape and level of fire resistance.

There are also barriers to adaptive reuse, which invariably concern costs. However, this is often a smoke screen obscuring the real reason that it is easier under current development processes to produce a new building. Adaptation of existing buildings is frequently considered to be less creative than producing a new building and

therefore attracts less kudos. The range of barriers to adaptive reuse (Dash Wu, 2010) is specified in the Box given below.

- *Only viable where the costs and benefits are factored in over the life of the building*
- *Building owners see no economical benefits in reuse*
- *Older buildings may require extensive and costly refurbishment*
- *Inability to match the performance of a new building*
- *Ongoing maintenance costs may be higher than a new building*
- *Older buildings may be unable to meet current sustainability standards*
- *Availability and price of matching existing materials may create problems*
- *Maintaining the structural integrity of older buildings may be difficult.*

There are some key issues to be addressed in building reuse. In order that the right decisions are taken when considering adapting a building certain factors have to be carefully considered and evaluated. These factors are not mutually exclusive and, in the case of some buildings, several factors stated by Riley and Cotgrave (2004) and Royal Institution of Chartered Surveyors along with British Property Federation (2006), may apply.

- ***Building availability:*** Obviously one needs to check if a building user requires accommodation and there is a readily available stock to choose from.
- ***Building suitability:*** This relates to the size and shape of the building and requires careful examination to ensure it will meet the client's requirements.
- ***Project brief:*** Critical requirements and expectations of time, cost and suitability are examined to ensure that user/buyer expectations are delivered within the set parameters.
- ***Economic advantages:*** Virtually all developments can only proceed if they are financially viable. This will require consideration of the cost of carrying out the development as compared with the likely return on the completed development.
- ***Quality of Building:*** One of the main reasons for re-using old buildings is simply the quality of the buildings themselves; derived from the architectural style, the materials and workmanship, or the character that can only be acquired with age.
- ***Condition of building:*** The structure of the building should be scrutinized for defects, whether they are structural or surface defects

- **Character and appearance:** *Users derive satisfaction from the beauty, harmony, character and scale of architectural masterpieces and picturesque buildings that are representative of local materials and traditions.*
- **Architecture:** *Certain buildings are landmarks in architectural history, or may be designed in styles which are expressive of the spirit of the age.*
- **Sustainability:** *Significant savings can be made in energy usage by the use of embodied energy in the building. The existing building may have energy saving and environmentally friendly setups like rain water harvesting, solar panels etc.*
- **Policies and controls over development:** *There is a wide range of legislation, regulations, and other policies, both national and local which will have a direct bearing on decisions affecting the choice between reuse and redevelopment.*

Decision making for adaptation of building is complex according to Blakstad (2001). Decision-makers are stake holders, each representing a different perspective like investors, developers, regulators, occupants/users and marketers (Kincaid, 2002). Designing and acquiring the adaptation of an existing building is not fundamentally different from the process of acquiring a new building. Langston (2011), however states adaptive reuse as a subset of refurbishment where a change in a facility's primary function is involved.

3. Refurbishment: The refurbishment of existing constructions is today a promising activity. It can be observed that the building industry is getting more and more devoted to these activities of consolidation, rehabilitation and modernisation of old buildings (Mazzolani and Ivanyi, 2002). Refurbishment of buildings entails giving outdated buildings a new purpose with upgrading and reconfiguration that goes beyond the cosmetic (Riley and Cotgrave, 2011). It covers a wide range of activities, from relatively minor works to very significant changes to the fabric or internal layout of a building. Refurbishment and modernisation can effectively extend a building's life expectancy by 'resetting the clock' and this phenomenon plays a major role in the reusing and recycling of existing building (as opposed to demolishing), commonly referred to as 'adaptive reuse' (Wilkinson et al. 2009). The principal reasons for refurbishment as given by Gold and Martin (1999) are:

❖ **Aesthetics:** *A poor exterior or interior appearance will influence market perception of the building and will deter many investors. Refurbishment of parts of the building such as the facades, entrance or other public areas, will overcome this. However, aesthetic upgrading could impose greater loads on a structure.*

❖ **Requirement to increase net lettable floor area:** *Enhancing the value of a building is to be able to collect more rent from it, achieved greatly by increasing the net lettable floor area. Two types of floor extension are possible. The first, and more common, is a minimal extension so that services, such as air supply ducts can be located outside the original building line, thus freeing usable space inside the building. The second approach is to construct additional usable floor space, which has to be designed to carry the full floor loading.*

❖ **Change in Regulations:** *There are many national regulations as well as property developers' expectations to be satisfied during building refurbishment. Changes to the Building Regulations have increased fire resistance periods and altered requirements for access and facilities for disabled people. Services-related Regulations include those imposed by the Workplace Regulations (Health, Safety and Welfare), lighting, heating and ventilation to meet standards.*

❖ **Change of use:** *Many refurbishments are brought about by changes in organisational requirements. At a social level, developing technology and changes in working patterns are predicted to affect the use of buildings, particularly office space. Growth in the use of automation and information technology has led to increased working from home or elsewhere and the export of repetitive, simple operations to developing countries. There is also a growing interest in overall changes of use, for example, changing redundant offices into residential flats or student accommodation. This has been aided by regeneration of urban areas making previously undesirable areas attractive.*

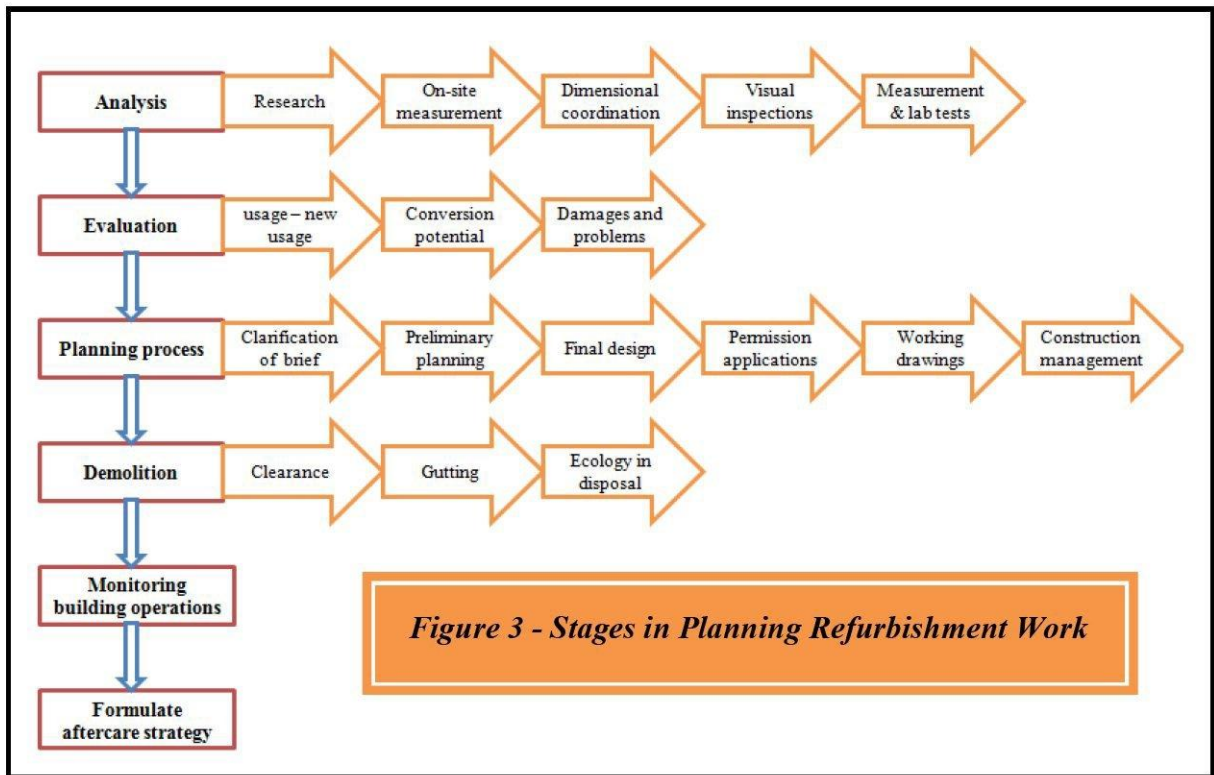
❖ **Need to upgrade services:** *One of the primary reasons for refurbishment from a services perspective will be the need to upgrade or replace existing plant because of a poor working environment caused by ineffective air conditioning, heating or ventilation. Refurbishment of services will provide the opportunity for a more energy efficient building with consequent cost savings, an area in which future legislation may have a significant impact (Concrete, 1999).*

3.1. Levels of Refurbishment: Refurbishment of a building always means adapting it to meet current standards, too, whether because of changes in user demands or new technical regulations. The extent of building refurbishment will vary for each job and it is not possible to give definitive levels. There will, for example, be situations where a major refurbishment is carried out on one

part of the building, such as the entrance hall, but only a minor refurbishment elsewhere. However, refurbishment is broadly classified by Douglas (2006) as follows:

Type	Approximate time to execute	Approximate payback period	Description
Minor/ cosmetic	1- 3 months	2 - 5 years	This will involve redecorating, improving signage and lighting, replacing floor coverings, exterior painting and repair, minor changes to the fittings.
Services	3- 6 months	5 - 15 years	Complete replacement of heating, ventilation and air-conditioning plant. Associated pipe work, ducting, terminal units, controls and insulation may be replaced or upgraded as necessary.
Structural	2- 6 months	5 - 15 years	Addition of new lift shaft, escalators or riser, necessitating structural alterations.
Major	2 - 12 months	5 - 15 years	This will involve major changes to the services and the interior fittings but without any significant structural alterations. May include addition of raised floor, improvements to core areas and entrance halls, new lighting, internal shading.
Complete	6 - 18 months	10 - 30 years	This will involve significant structural alterations, such as the extension of the floors or partial demolition to create an atrium or stripping of the building back to the concrete frame. New cladding may be fitted together with the installation of new services and full fitting out. Timing of a complete refurbishment is variable but likely to take place in conjunction with a lease renewal.
New Build	18 - 24 months	10 - 30 years	Construction of a new building, excluding demolition of an existing building.

3.2. Planning Refurbishment Works: The planning of conversions is fundamentally different from the planning of new works. For example, the entire planning process for a new structure is abstract until work commences on site, but the starting point for a conversion is an existing building, which alters the situation completely. The process of planning refurbishment works as illustrated in Figure 3 and stated by Douglas (2006) and Giebeler et al. (2009) involve the following phases:



a. Analysis: The planning process begins with an analysis of the existing construction. Elaborate investigations, result in greater reliability of the planning and hence also the costs and deadlines.

- **Research** - Researching the building means carrying out a detailed historical analysis of the existing construction and studying old documents, drawings and calculations that provide an overview of the design and construction process at that time and serve as the foundation for further investigations or inspections.

- **On-site measurements and as-built drawings** - The measurement of structures or components accompanies the conversion measures during all phases of the work to achieve a consistent basis for planning.

- **Dimensional coordination** - Knowledge of the dimensional coordination customary at the time the building was erected can assist in the interpretation of the existing structure, i.e. in order to estimate the dimensions of the underlying structure, e.g. masonry wall thicknesses and their linings, without having to open up the construction.

- **Visual inspections** - Many patterns of damage and forms of construction can be determined purely by visual inspections and feeling, touching the surfaces. This is an inexpensive approach; a thorough inspection and full documentation is advisable. The partial opening-up of a timber joist

floor, to assess the nature and construction of the ceiling and infill materials are important, especially when considering load-bearing capacity, sound insulation and fire resistance.

- **Measurements and laboratory tests** - The measurement of component properties and laboratory tests can supply further information regarding suspected problem. Many component analyses cannot be cleared up by the way of simple in situ inspections. In such cases samples must be taken and tested in suitable laboratories.

b. Evaluation: The evaluation of the existing construction is an intrinsic part of the architect's services. In order to be able to reach a reasonably reliable decision at an early stage, the architect should concentrate on the following three issues.

- **Usage- new usage** - Not every representative of the building stock is suitable for every new type of use. This will always be a problem where very specific, unalterable user interests are involved.

- **Conversion potential** - The architect should estimate to what extent it is possible to intervene in the existing fabric so that it is possible to intervene in the new user requirements. The conversion potential depends on the type of construction and therefore also the period in which the building was erected. "Forcing" a conversion on a building will always lead to an unsatisfactory result- both financially and architecturally.

- **Patterns of damage, principal problems** - The analysis usually results in a number of patterns of damage that cannot be fully appraised at this early stage of the planning. The aim must be to establish the principal problems and estimate their costs and completion dates.

c. Planning process: Conversions exhibit a number of idiosyncrasies, both in terms of the sequence of operations and the boundary conditions

- **Phase 1: Clarification of design brief** - discussions between the client and the architect in which the nature of the future cooperation, the costs of the building work, the completion date and general user requirements.

- **Phase 2: Preliminary planning** - Besides further work originating from phase 1, the main new areas of work in this phase are developing the planning concept, conducting the first meetings with other specialists in the design team and authorities, plus estimating the costs.

- **Phase 3: Final design** - working through the planning concept, including the provision of drawings. One obvious approach is to use the as-built drawings as a basis for the final design.

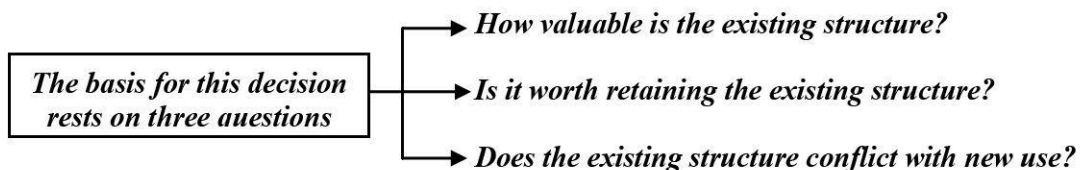
- **Phase 4: Building permission application** - involves all the work that leads to gaining approval to go ahead with the project from the relevant authorities. But contrasting with a

new-build project, the aim of negotiations with the building authorities is to achieve a number of exemptions. These concern both urban planning regulations, e.g. clearance to neighboring buildings, and building technology regulations, e.g. fire resistance, thermal performance, sound insulation.

- **Phase 5: Working drawings** - includes all the fabrication and detailed planning work prior to issuing tenders. The basic differences between new-building and conversion projects disappear from this stage onwards.

- **Phase 6: Construction management** - The planning phase accompanying the construction on site is often referred to as site management. It also includes supervising the budget and timetable right up to the time of defects-free handover. The main difference between the planning of new structures and conversions lies in the quantity of existing building fabric that must be retained and refurbished.

d. Demolition: The fabric of the building to be retained- which should not be confused with the building as it exists as such- forms the basis for the conversion. How much of the existing building should be demolished must be established during the planning process. The following questions should be asked for every component in the existing structure so that a sensible demolition plan can be drawn up as illustrated below.



- **Clearance** - The first phase concerns all works on non-load bearing components. All surface finishes and materials that are definitely unserviceable are removed; in total refurbishment this could mean leaving behind the structural carcass only. Once “clearance” of the existing structure has been carried out, it is much easier to appraise and measure.

- **Gutting** - Gutting means demolishing the entire insides of a building, leaving only the external walls standing; even load bearing and bracing components in the building are removed completely. Gutting calls for extensive, expensive safety measures, and apart from that, building fabric already paid for and actually usable is removed, which increases the overall costs considerably.

- **Ecology** - The debris from demolition work plus excavated material represents the largest item in the total waste flow. Giebeler et al. (2009) state that some 76 per cent of building

debris is recycled, only eight per cent ends up in landfill sites. The relatively high proportion of recycling is due to the large amount of mineral debris that occurs during demolition.

e. Monitoring building operations: The difference in the process of construction of new buildings and reuse of adapted buildings lies chiefly in the planning stage. Once the demolition is done, the progressive work of construction is the same as any new construction project and as required by the design of the building for reuse. Proficient supervision of the works in progress is required to ensure adequate quality control.

f. Formulating aftercare strategy: The building surveyor should compile a maintenance manual for the completed building, which is the information contained within any health and safety file under the Construction, Design and Management Regulations (CDM). In addition, to ensure the ongoing performance of the building, a planned preventive maintenance programme would need to be instigated. Even the best conversion can be used only for a limited time. Technical progress, changing legislation and standards, new demands regarding comfort and convenience and obsolete functions are not only the reasons behind today's conversions, but those of the future as well.

D. Green Technology and Sustainability

Urbanization and growing wealth in developing countries signify a large increase in demand for modern energy services in residential, commercial and public-service buildings. Pursuing energy efficiency in buildings is vital to energy security in developing countries and is identified by the Intergovernmental Panel on Climate Change (IPCC) as having the greatest potential for cost-effective reduction of CO₂ emissions by 2030 among all energy-consuming sectors (Liu et al, 2010) as it is the first step toward achieving sustainability in buildings and organizations. Energy efficiency helps control rising energy costs, reduce environmental footprints, and increase the value and competitiveness of buildings.

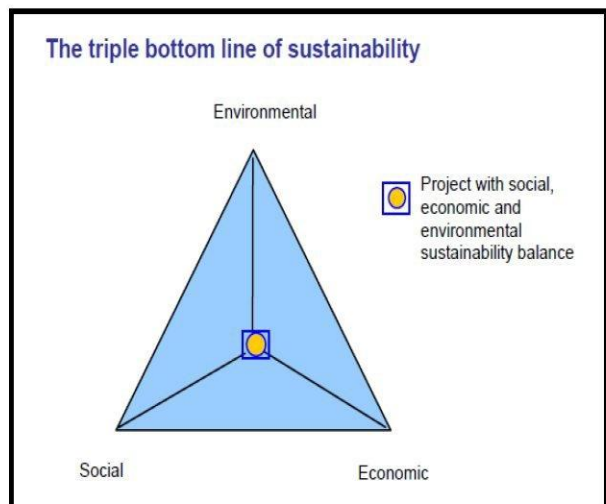
1. Attributes of green technology: Environmental technology or “green technology” is the application of the environmental sciences to conserve the natural environment and resources and curbing the negative impacts of human involvement. The term “technology” refers to the application of knowledge for practical purposes (Hari, 2012).

There are five major attributes of green technology as stated by Fulekar et al. (2013). They are:

- **Sustainability** - Meeting the needs of society in ways that can continue indefinitely into the future without damaging or depleting natural resources.
- **"Cradle-to-cradle" designs** - Ending the "cradle-to-grave" cycle of products, by creating products that can be fully reclaimed or reused.
- **Source reduction** - Reducing waste and pollution by changing patterns of production and consumption. **Waste reduction plans focus on 9 R's: Restore, Reduce, Renew, Recover, Recycle, Reuse, Rethink, Replenish, and Replace.**
- **Innovation** - Developing alternatives to technologies that use fossil fuels to save the environment from carbon emissions.
- **Viability** - Creating a centre of economic activity around technologies and products that benefit the environment and speeding their implementation.

2. Sustainability: The UN Commission (1983) defines sustainability as “Meeting the needs of the present without compromising the ability of future generations to meet their own needs”. The concept of sustainable construction is an approach to building which promotes the attainment of goals associated with ‘the triple bottom line’, because it involves a commitment to economic, environmental and social objectives (UNEP Industry and Environment 2003, Carter and Fortune 2007).

- **Economic sustainability** includes increasing profitability by making more efficient use of resources including labour, materials, water and energy.
- **Environmental sustainability** is preventing harmful and potentially



irreversible effects on the environment by careful use of natural resources, minimizing waste, protecting the environment from the impact of emissions, effluent and waste.

- **Social sustainability** implies carefully recognizing and responding to the needs of everyone impacted by construction, (from inception of a project to demolition),

providing high customer satisfaction and working closely with clients, suppliers, employees and local communities. The list will include construction site workers, local communities, the supply chain and people that will use the finished product.

3. Principles of sustainable design: There are five principles of sustainable design and environmental architecture (Khalfan, 2002). They are healthy interior environment, energy efficiency, ecologically benign materials, environmental form and good design as illustrated in Figure 4.

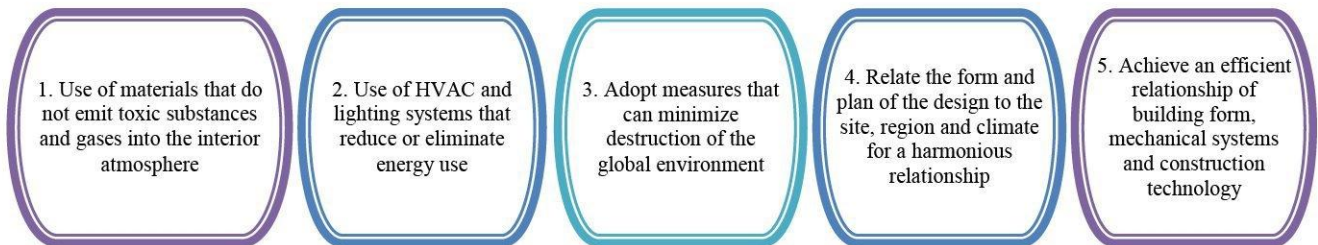
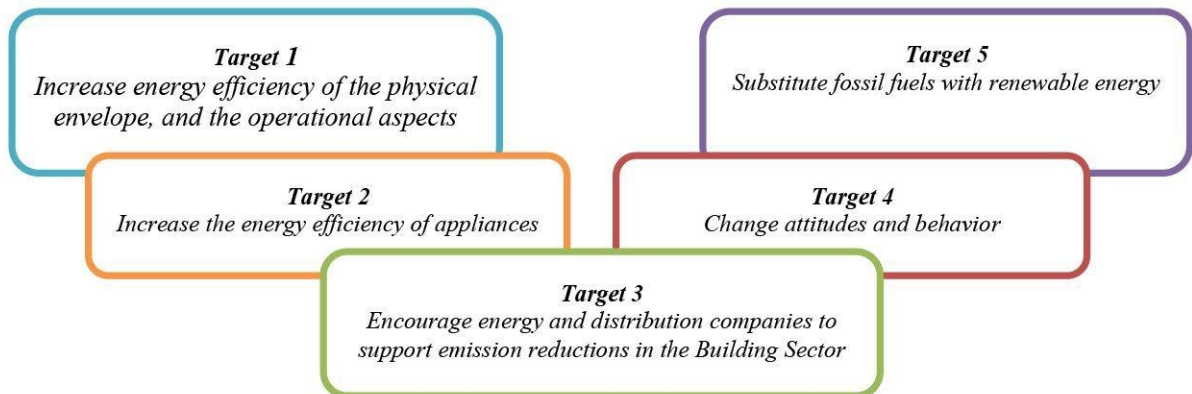


Figure 4 – Principles of Sustainable Design

To select the most appropriate policies for the “carbon emissions” scenario of the building sector of individual countries, governments should consider the policy objective they wish to target. Broadly speaking, the five major policy objectives, or targets, for reducing GHG emissions from buildings as recognized by UNEP (2009) are:



4. Barriers to sustainable construction: As a discipline, sustainable construction has been evolving since the late 1980s. It continuously gained momentum as increasing evidence about depletion of the environment and environmental loading became obvious (Myers, 2013). However, regardless of its importance and the expanding foundation of knowledge in the field, sustainable construction is by no means a standard practice in many countries (Landman, 1999). Although environmental protection measures have

become common, several barriers contribute to hindering sustainable construction (Christini et. al. 2004). Matar et. al. (2004) and Matar (2007), categorize the barriers into general and technical barriers.

General barriers as proposed by Landman (1999), Du Plessis (2002) and Reed Research Group (2003) are:

- *Lack of expressed interest from different project parties.*
- *Lack of training /education in sustainable design / construction.*
- *Slow recovery of investment in technology to promote sustainable construction practices.*
- *Higher initial cost of sustainable building.*

Technical barriers as projected by Pearce and Vanegas (2002), Scheuer and Keoleian (2002) and Chen et. al. (2005) include:

- *Lack of well-defined set of sustainable construction practices that can be practically engineered into projects.*
- *Need for a mature and integrated framework of application for sustainable practices in construction.*
- *Disagreement about an optimum project delivery structure as very few studies have considered the effect of project planning on the capacity to adopt sustainability practices.*
- *Need for effective drivers for a change for different parties in the construction industry.*

Sustainability should be considered when first deciding whether a new building or piece of infrastructure is needed, throughout the specification and design, on the construction site, in operation (including maintenance and refurbishment), and ultimately in deconstruction or demolition. Abramson (2012) states that adaptive reuse and refurbishments redirects obsolescence towards sustainability rather than demolition by making the building usable.

E. Rating Systems for New and Existing Buildings in India

Whether Green buildings are really green is to be decided against the predefined rating systems. There are three primary Rating systems in India as exemplified in Exhibit (3), followed by the Rating system for existing buildings (IGBC).



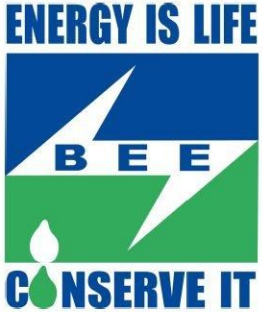
Green Rating for Integrated Habitat Assessment (GRIHA)	Indian Green Building Council (IGBC)	Bureau of Energy Efficiency (BEE)
		
<ul style="list-style-type: none"> ▪ India's own rating system jointly developed by TERI and the Ministry of New and Renewable Energy, where buildings are rated in a three-tier process-the online submission of documents as per the prescribed criteria followed by on site visit and evaluation of the building by a team of professionals and experts from GRIHA Secretariat. ▪ GRIHA rating system consists of 34 criteria categorised in four different sections. ▪ Commonwealth Games Village, New Delhi, Fortis Hospital, New Delhi, CESE (Centre for Environmental Sciences & Engineering) Bldg, IIT Kanpur and many other buildings have received GRIHA rating. 	<ul style="list-style-type: none"> ▪ Confederation of Indian Industry (CII) formed the Indian Green Building Council (IGBC) in the year 2001. ▪ IGBC is the non-profit research institution that has licensed the LEED Green Building Standard from the USGBC. IGBC facilitates Indian green structures to become one of the green buildings. <ul style="list-style-type: none"> ▪ Certification is applicable to the following rating systems: <ul style="list-style-type: none"> ✓IGBC Green - <ul style="list-style-type: none"> New Buildings, Existing Buildings, Homes, Schools, Factory Building, Townships, SEZs, Landscapes, Mass Rapid Transit System ▪ CII – Sohrabji Godrej Green Business Centre, Rajiv Gandhi International Airport – Hyderabad, Anna Centenary Library Building, Chennai etc. have LEED ratings 	<ul style="list-style-type: none"> ▪ BEE developed its own rating system for the buildings based on a 1 to 5 star scale. More stars mean more energy efficiency. ▪ BEE has developed the Energy Performance Index (EPI). The unit of Kilo watt hours per square meter per year is considered for rating the building and especially targets air conditioned and non-air conditioned office buildings. ▪ The Reserve Bank of India's buildings in Delhi and Bhubaneswar, The CII Sohrabji Godrej Green Business Centre and many other buildings have received BEE 5 star ratings.

Exhibit 3 - Primary Rating systems in India

Rating system for existing building - IGBC Green Existing Buildings O&M

About IGBC: IGBC Green Existing Building O&M is the first rating programme developed in India, exclusively for existing building stock. It is a voluntary and consensus based programme. The rating is focused on sustained performance of buildings with respect to the green features. The overarching objective of this rating system is to facilitate building owners & facility managers in implementation of green strategies, measure their impacts and sustain the performance in the long run. The system addresses national priorities of resource conservation while providing quality of life for occupants

Scope: IGBC Green Existing Buildings O&M rating system addresses green features under specific categories like Site & Facility Management, Water Efficiency, Energy Efficiency, Health & Comfort, Innovation. The IGBC Existing Buildings O&M rating system is applicable for all types of non-residential buildings. Buildings which are 80 per cent occupied (with respect to the carpet area) and operational for a minimum of 1 year are eligible for the certification. Projects already certified and operational for more than 1 year are also eligible to apply the certification.

Benefits: Green Existing Buildings can have tremendous benefits, both tangible and intangible.
Tangible benefits - energy savings of 15-30 per cent and water savings of 15-50 per cent.
Intangible benefits - enhanced air quality and health & higher satisfaction levels of occupants

Certification Levels : The threshold criteria for Certification levels are as under

Certification Level	Points	Recognition
Certified	50 – 59	Best Practices
Silver	60 – 69	Outstanding Performance
Gold	70 – 79	National Excellence
Platinum	80 - 100	Global Leadership



Validity of Certification: IGBC Green Existing Buildings O&M rating is valid for a period of 3 years from the date of issue of the certification.