SELINUS UNIVERSITY
OF SCIENCES AND LITERATURE

Role Of Architecture
on Facing Climate Change

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A Dissertation

Presented To the Department of Sustainable Architecture
Program at Selinus University

Faculty of Engineering & Technology
In fulfillment of the Requirements
For the Degree of Doctor of Philosophy
In Sustainable Architecture

2023

Abstract

Climate change is a Global Impact, challenge, disruption, and implications that surround and threaten the planet.

Mitigation and adaptation in climate change is the most comprehensive study to date examining the potential global warming impacts of climate change and how architecture can help save the earth and support the idea of climate engineering in order to avoid climatic and environmental disaster that can eliminate the Planet and the humanity, which leads us finding solutions through architecture to keep pace climate changes.

We Have to consider that increasing urbanization and industrialization has caused the urban environment to deteriorate.

Deficiencies in development control have important consequences for the urban climate and the environmental efficiency of buildings.

Environmental challenges can be addressed through buildings design, monitoring and processing energy and climate in the built urban environment and the future environment.

We can consider three aspect that can address the way we design and construct our buildings.

First one through a range of design solutions that can be adopted to improve energy performance and indoor air quality of individual buildings and look at the aspects of urban design that can reduce these climate impact as Humans has the ability artificially cooling the earth.

Second one how our architecture be innovative in terms of optimizing our current technologies to achieve unprecedented building performance and continue using of the raw materials to produce construction materials and optimize our energy resources to fit the needs of our environment.

Third one a study of how green buildings can be created, where green buildings may incorporate sustainable materials in their construction to be a part of the solution to combating climate change and the role of the green spaces contribute significantly to cooling our cities and saving energy.

to focus how can we create architecture that would positively and intelligently adapt and change along with our rapidly changing climate we must go through research at various level, presenting a numbers of case studies that will be analysed within environmental, socioeconomic and cultural scopes, as our goal is to have a sustainable cities that provide a liveable and healthy environment for their inhabitants and meet their needs without impairing the capacity of the local, regional and global environment system to satisfy the needs of future generations.

As Winston Churchill said, “We shape our dwellings and afterwards our dwellings shape our lives”.

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Acknowledgements

I would like to thank my supervisor Professor Salvatore Fava, for his consistent support and guidance during the running of this thesis.

I am indebted to all my family members for supporting me and offering all the working conditions necessary to complete this thesis.

Additionally, I would like to extend my thank to the administrator's services at Selinus University who spared no effort to make this research possible.

Chapter 1

Introduction

THE PHRASE ‘Global Warming’ has become familiar to many people as one of the most important issues of our day. Many opinions have been expressed concerning it, from the doomladen to the dismissive. A more accurate but longer phrase to use is ‘human induced climate change’.

1. Global Warming

What is global warming?

We know for sure that because of human activities, especially the burning of fossil fuels, coal, oil and gas, together with widespread deforestation, the gas carbon dioxide has been emitted into the atmosphere in increasing amount over the past 200 years and more substantially over the past of 50 years. Every year these emissions currently add to the carbon already present in the atmosphere at least a further 8000 million tonnes, much of which will remain there for a period of 100 years or more. Because carbon dioxide is a good absorber of heat radiation coming from the Earth’s surface, increased carbon dioxide acts like a blanket over the surface, keeping it warmer than it would. with the increased temperature the amount of water vapour in the atmosphere also increases, providing more blanketing and causing it to be even warmer.

The gas methane is also increasing because of different human activities, for instance mining and agriculture, and adding to the problem. An increase of in global temperature will lead to global climate change. If the change were small and accrued slowly enough, we would almost certainly be able to adapt to it. However, with rapid expansion taking place in the world’s industry the change is unlikely to be either small or slow, the absence of more substantial effort to curb the rise in the emissions of carbon dioxide, the global average temperature will rise by a third of a degree in a century. This may not sound very much, especially when it is compared with normal temperature variations from day to night or between one day and the next. But when we talk of global warming, it is not the temperature at one place, but the temperature averaged over the whole globe that will rise. It does not mean that there will be uniform or even similar warming everywhere; there will continue to be large variations in temperature over different areas of the Earth’s surface that will continuously vary from day to day and from year to year. The predicted rate of change of 3°C a century is probably faster than the global average temperature has changed at any time over the past 10 000 years. An as there is a difference in global average temperature of only about five or six degrees between the coldest part of an ice age and the warm periods in between ice ages a few degrees in this global average can represent a big change in climate. It is to this change and especially to the very rapid rate of change that many ecosystem and human communities (especially those in developing countries) will find it difficult to adapt.

Scientists are confident about the fact of global warming and climate change due to human activities. Although there are still uncertainties concerning the detail regarding the pattern of change in different parts of the world, it is clear that the most noticeable adverse impacts will concern sea level rise (water expands as it becomes warmer), more heatwaves and because of increased energy in the atmospheric circulation, more intense rainfall and more extreme events such as we have already mentioned.

1.1 Adaptation and mitigation

An integrated view of anthropogenic climate change (climate change resulting of human activities) is presented in figure 1.4 where a complete cycle of cause and effect is shown. Begin in the box at the bottom where economic activity, both large and small scale, whether in developed or developing countries, results in emissions of greenhouse gases (of which carbon dioxide is the most important) and aerolos. Moving in a clockwise direction around the diagram, these emission lead to changes in atmospheric concentrations of important constituents that alter the energy input and output of the climate system and hence cause changes in the climate. These climate changes impact both humans and natural ecosystems altering patterns of source availability and affecting human livelihood and health. These impacts in their turn affect human development in all its aspects. Anticlockwise arrows illustrate possible development pathways and global emission contains that would reduce the risk of future impacts that society may wish to avoid. Figure 1.4 also shows how both causes and effects can be changed through adaptation and mitigation. In general adaptation is aimed at reducing the effects and mitigation is aimed at reducing the causes of climate change, in particular the emissions of the gases that give rise to it. Both adaptation actions and mitigation actions are urgently required in response to human induced climate change.

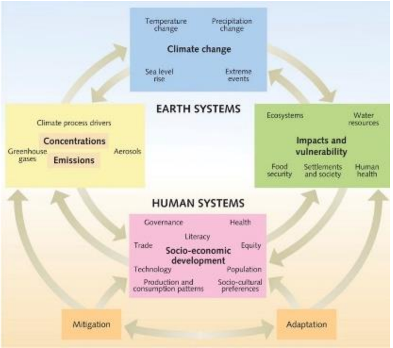


Figure 1.4

1.2 Possible causes of climate change

There are many theories that try to explain climate change, but none of them can give a complete explanation of all the changes. The major problem is the relationships and interactions among the physical components of the climate system. Thus, although we give here some possible causes of climate changes, only knowledge and understanding of the majority of them can give a full understanding of the problem. when we study the subject “climate change” we are using temperature and precipitation as indicators of climate evolution.

1.3 Variations in solar output

Recent measurements using radiometers on satellites saddest that solar energy, which is an input to our system, can try considerably. Changes of the order of 0.1% of the total solar energy reaching the Earth have already been measured, within a period of less than 20 months. This kind of change could be linked sunspot activity, which has a periodicity of 11 years. Sunspot are magnetic storms giving (or showing) cooler regions on the Sun’s surface. Thus, sunspot maximum corresponds to a minimum of received solar energy. According to measurements during the period 1976 to 1980, the Sun's surface cooled by about 6°C corresponding to an increase in the number and the size of sunspots. These changing may alert the Earth's climate since, according to numerical climate models, a 0.5% change in

solar output could be enough to change the climate. In addition, in a decrease in the earth's average temperature by 1.0°C. Of course, more satellite data are needed, so that the solar energy variations can be monitored to provide a better understanding of how solar energy is connected with climate change.

1.4 Variations in the Earth's orbit

Milankovitch's theory is the theory relating variations in the Earth's orbit to climate change. The basic concept of this theory is that changes in the Earth's orbit produce variations in the solar energy reaching the Earth's surface.

The first cause is changes in the shape (eccentricity) of the Earth's orbit. As shown in figure 2.5, the Earth's orbit changes from nearly circular to elliptical and then back to circular. This cycle takes about 100,000 years to complete. If the eccentricity of the orbit is high, then the difference between the energy received at the top of the atmosphere at the two positions, closer and further away from the sun, is also high. We are now in a period of low eccentricity and the difference in distance between the closet and farthest distance of the Earth from the sun is 3%, giving a 7% difference in solar energy between July and January. If the difference in distance were 9%, which is the case with high eccentricity, then the difference in solar energy could be 20%. A more of eccentric orbit will also change the length of the seasons.

The second cause is the fact that the Earth wobbles, like a spinning top, as it rotates on its axis, according to the Milankovitch theory, this wobble has a period of about 22,000 years. At present the Earth is closer to the sun in January and farther away in July. After about 11,000 years the Earth will be closer to the sun in July, hen the Northern hemisphere exhibits summer.

The third cause, according to Milankovitch theory, is the fact that there are changes in the tilt of the Earth with a period of the order of 41,000 years. In figure 2.6 the angle of the Earth's orbital tilt is currently 23.5 degree, but it can vary from about 22.5 degree to 24.5 degree. If the Earth's still has a smaller value, then the seasonal variation between summer and winter will be less. Thus, summers will be cooler, and winters will be milder.

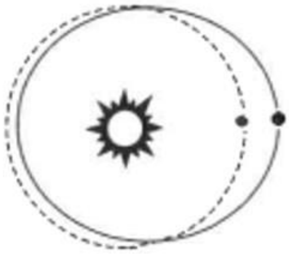


Figure 2.5

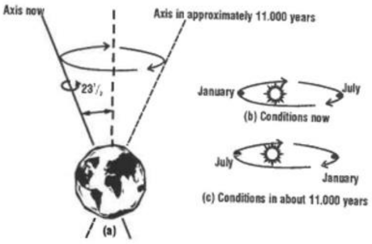


Figure 2.6

1.5 Surface modifications

Modifications of the Earths surface may cause climate changes. The major surface modification is the slow shifting of the continents and the ocean floors. According to the theory of tectonics, the outer shell of the Earth is composed of plates that are moving in relation to one another. The rate of motion is extremely slow, a few centimetres per year. This theory can explain the facts such as the past existence of glacial features close to Africa and different paths of ocean currents because the continents have been arranged differently. The rearrangements change the transport of heat and the global wind system. Furthermore, if large areas of open water are covered with ice, the magnitude of the sensible and latent heat fluxes are reduced. Finally, as will be shown in later sections, modification of the surface may influence the microclimate of certain areas. For example, overgrazing of grasslands or deforestation of large areas may increase the surface albedo and cause an increase in desert conditions (a process known as desertification).

1.6 variations of land surface albedo due to vegetation

The surface albedo is the ratio of the reflected to the incident solar radiation. Changes in surface albedo are caused either by the extend of snow cover and ice or by a surface change due to desertification, deforestation or greenhouse warming. These changes introduce a variability into the climatic system, with the appearance of corresponding feedback mechanisms (positive and negative feedback mechanisms reflect the ability of the Earth's atmosphere system to check and balance any forces influencing the system, in order that it can readjust to a new equilibrium).

It should be mentioned that there is a difference between incoming solar flux reaching the top of the atmosphere and the flux reaching the surface. This is attributed to the absorption scattering and reflection mechanism involving water vapour, ozone, dust, air and clouds. Thus, the solar radiation reaching the ground is mainly direct radiation plus diffuse radiation, generally about 75% of the incident solar radiation at the top of the atmosphere. Changes in the surface albedo modify the planetary albedo, which is the ratio of radiation reflected from the system make up of the Earth and its atmosphere to the incident solar radiation.

Climate changes may therefore be caused by changes in the land surface albedo, which, although it represents only 29% of the total surface of the Earth, is the part that varies most over both time and space. The surface albedo depends on the wavelength of the radiation, the elevation of the sun and the nature of the earth's surface. The results of climate models and observations seems to indicate that increased albedo resulting from removal of vegetation can decrease cloudiness and precipitation since there is a net radiative loss. On the other hand, a decrease in albedo due to increased vegetation gives positive feedback with increase rainfall. To distinguish the feedback mechanisms that involve surface vegetation and soil, the sensitivity of the climate to land surface changes and possible feedback mechanisms between the climate system and the above-mentioned changes. In figure 2.8 the relative magnitudes of the three types of heat flux are shown over different terrains. The surface is heated by the absorbed solar radiation until the different types of flux are in equilibrium. In dry climates the talent heat flux is very small compared with the sensible heat flux. Figure 2.8 also shows the difference between convective and stable planetary boundary layers, in relation to heat fluxes, in the second case, where small vertical gradients of temperature and moisture exist, the values of fluxes are very small and only heating of the surface or an increased wind speed can change this situation. With a climate change, the processes at the surface can be influenced in different ways. Changes in cloudiness or precipitation can affect the hydrological cycle as well as the albedo. With less precipitation, vegetation will be reduced, and albedo will be increased, resulting finally in less solar short-wave radiation being converted into mainly sensible heat flux. Changes in surface temperature affect the vegetation but not the magnitudes of the fluxes, since they depend upon temperature gradients. An increase in surface albedo leads to a reduction of the solar input, which in turn leads to the decrease in the sensible heat flux.

If the vegetation of an area is removed or is changed, then the supply of water to the atmosphere through the talent heat flux will change, resulting in a change of the area's precipitation. This may then lead to a local climate change, which may produce drying of the surface, the final stage being desertification. Changes of vegetation may change the roughness of the surface, which is important in calculating heat fluxes that depend on the roughness parameter Z_0. From these scenarios, it is evident that there is feedback on different scales between climate change and the changes in land surface characteristics and that it is very difficult and uncertain to predict these changes quantitatively.
The most important climatic variables for the structure of natural vegetation are:

Radiation: the intensity and extreme value of both short-and long-wave radiation; day length; seasonal change.
Temperature: mean and extreme values; daily fluctuations; seasonal changes.

Precipitation: mean annual total; seasonal changes; state (rain, snow or ice). Atmospheric properties: air moister; CO2 level; the levels of other gases. In addition, the impact of vegetation on climate depends mainly on relevant biospheric properties, such as the structure of ecosystem, water use, water storage and metabolism mechanisms such as gas exchange (CO_2).

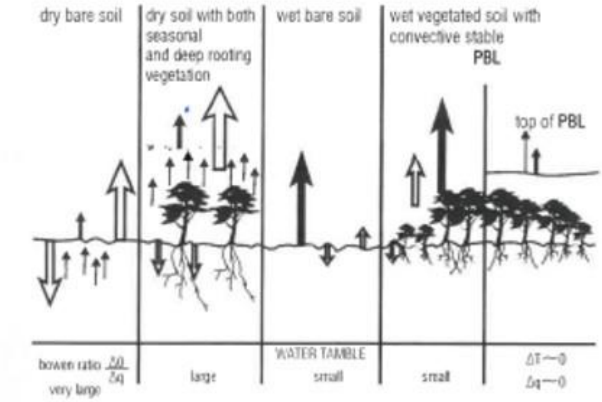


Figure 2.8

1.7 Variations within the atmosphere

Climate change attribute to the constituents of the atmosphere either block out some of the incoming solar radiation or trap a fraction of the Earth-radiated infrared energy.

1.7a The Greenhouse Effect

If the energy balance of the Earth is considered, the main factor that determines the global temperature is solar radiation. The Earth's re-emits long wave radiation proportional to the fourth power of its absolute temperature. Thus, there is compensation between the emitted infrared radiation and the absorbed solar radiation. If we take into account the incident solar radiation that is absorbed (70%) and the emitted planetary long-wave radiation, then an effective planetary temperature can be estimated**,** which is about -18 degree C (225K). however, since the actual surface temperature is about 1.5-degree c, the difference between surface and upper atmosphere is due to the fact that the infrared radiation emitted by the surface is absorbed in the lower levels of the atmosphere, mainly by water vapour and carbon dioxide. This absorbed energy is re-emitted back to the surface and thus the surface is heated to a temperature higher than the effective planetary temperature. This phenomenon is called the "greenhouses effect" the greenhouse effect on the Earth can be identified in terms of the difference between the energy emitted by the Earth's surface and the energy emitted back into space by the upper atmosphere. Thus, is the long-wave energy, which is trapped in the atmosphere and by feedback mechanism, that respond to climate-

changes. This effect is attributed to the property of greenhouse gases that absorb strongly in the infrared region of the electromagnetic spectrum.

The history of the knowledge of greenhouse effect can be called back to the early nineteenth century. In 1824, the French mathematician Joseph Fourier gave the concept of "greenhouse effect" as the "surface heat on Earth was maintained by the atmosphere – otherwise the planet orbit was too remote from the sun for a temperature that could support life".

Later in 1859, the Irish physicist John Tyndall observed that the atmospheric carbon dioxide (CO_2) methane (CH_4) and water vapour (H_2O) as key factors in maintaining temperature despite their tiny percentage of the total atmosphere.

In 1896, Swedish chemist Svante Arrhenius made a simple calculation to show that CO_2 accumulating in the atmosphere could increase the Earth surface temperature roughly by 5-degree C. it has now become a major field of research and a major driving force behind the sustainable development agenda. In 1925, the American statistician Alfred James Lotka described "anthropogenic climate change" as a major, cause of current climate variation.

Greenhouse effect can be described as the process in which the absorption of infrared radiation by the atmosphere warms the earth. The change in the composition of atmospheric gases leads to energy rebalance. For example, the increase in GHG, which is mostly related to H_2O and CO_2, along with others including CH_4, nitrous oxide (N_2O), Ozone (O_3), and several others, may reduce the infrared radiation through the atmosphere leading to the increase in the temperature of the earth's surface and the lower atmosphere. The term "greenhouse effect" may refer to natural green house effect or enhanced (anthropogenic) greenhouse effect, which are due to naturally occurring greenhouse gases and the gases emitted as a result of human activities, respectively.

We can say that the major cause of climate change is the increasing concentration of greenhouse gases (GHG) produced by human activities, such as deforestation, changes in land use, and a specially the burning of fossil fuels. This finding is recognized by the national science academies of all major industrialized nations.

Greenhouse gases, primarily, water vapour but including smaller amounts of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), are emissions that rise into the atmosphere and act as a thermal blanket, absorbing heat and reemitting it in all directions. The downward portion of this reradiation is known as the greenhouse effect and serves to warm the Earth's surface and lower atmosphere to a life-supporting average of 59°F (15°C), without this natural greenhouse effect, life on Earth as we know it would not be possible.

Beginning with the industrial revolution, However, the burning of fossil fuels in ever-increasing amounts has contributed to higher concentrations of carbon dioxide, methane, and nitrous oxide in the atmosphere, intensifying the natural greenhouse effect and contributing to global warming and climate change. Data from the international Energy indicates that buildings are responsible for almost 40% of global greenhouse gas emissions. Most of the building sector's energy consumption is not a attributable to the production of materials or the process of construction, but rather to operational processes, such as the heating, cooling, and lighting of buildings. This means that to reduce the energy consumption and GHG emissions generated by the use and maintenance of buildings over their life span, it is necessary to properly design, site, and shape buildings and incorporate efficient heating, cooling, ventilation, and lighting strategies. However, as operational energy use is reduced, attention will increasingly also need to be directed to reducing the embodied energy of construction materials.

1.7b Particle in the atmosphere

Small particles of dust (smaller than 5 µm in diameter), resulting from human activities, may remain suspended in the troposphere for several days. If there is a constant rate of emission of such particles into the atmosphere, a climate change may result. Depending on the size, shape, colour and vertical distribution of the particles and on the surface albedo, there are different actions that may take pace. For example, if the particles are bright relative to the Earth's surface, more solar energy will be scattered back into space, causing a decrease in air temperature. However, if they are relatively dark compared to the earth's, the higher absorption by the particles will increase the air temperature. Furthermore, the same particles may absorb infrared radiation emitted from the Earth's surface.

This amplifies the greenhouse effect, leading to a warming of the air. Thus is the obvious that the mechanisms related to particles in the atmosphere are very complicated.

1.7c Volcanic eruptions

During volcanic eruptions, ash particles, dust and gases are ejected into the stratosphere. If these eruptions are rich in sulphur gases, they can have a great influence on climate change. While volcanic ash falls out of the stratosphere quickly and has no serious effect, the sulphur gases react with water vapour, producing bright sulphuric acid particles that gradually form a dense haze layer. This layer, which may remain for a long period, absorbs and reflects back into space a fraction of the solar energy. According to mechanisms mentioned previously, this could lead to a decrease in the temperature of the Earth's surface. Although the calculation is very complex, mathematical models predict that large volcanic eruptions may give an average temperature drop of the order of 0.2 to 0.5°C over a period of three years.

Sources of GHG

CO_2: fossil fuel use in transportation.
Building heating and cooling, Manufacture of cement and other goods.
Natural process such as the delay of plant mater, and deforestation releasing CO2 and reducing its uptake by plants.

CH_4: Human activities related to agriculture, natural gas distribution, and land feels and natural process that occur, for example, in wetlands.

N_2O: Human activities such as fertilizer use and fossil fuel burning, Natural process in soil, and oceans.

1.8 climate modification in the urban environment

When we examine the climate of a small area, several square kilometres in size, then we are looking at the mesoclimate of the area. Such areas could be valleys, forests beaches or towns. On this scale, human activities are the major influence on climate change, for example creating the urban environment, which may differ considerably from the rural regions around it.

1.8a Urban climate

Most cities are sources of heat and pollution and the thermal structure of the atmosphere above them is affected by the so-called ‘heat island’ effect. The heat that is absorbed during the day by the building, roads and other constructions in an urban area is re-emitted after sunset, creating high temperature differences between urban and rural areas. The greatest temperature difference is absorbed during the night since the heat island is attributed mainly to urban -rural cooling, rather than to heating difference, especially in the period around sunset (see figure 2.9). additional city heat is giving off by vehicle and factories, as well as by industrial and domestic heating and cooling units. It has been observed that ‘cities’ with populations of thousands have maximum temperature differences from the surrounding rural area of 2 to 3K, while cities with a population of one million can have temperature difference of 8 to 12K. sometimes during a calm night large temperature excess, a light breeze, called a ‘country breeze’, due to the formation of a low-pressure area over the city, blows from the rural to the urban area. This wind may transport more pollutants into the city if there are big industries the surrounding countryside. Thus, an urban boundary layer (UBL)is created in the lower atmosphere above an urban area, with micrometeorological characteristics determined by the city. During the day, the UBL increase in depth as a result of the city warming and reaches heights that are about 25% greater than the mixing heigh over rural areas. At night, the UBL retains a surface mixed layer, giving rise to layering above this level, since the surrounding rural area is characterized by a strong surface-based radiation inversion (figure 2.10). thus, with weak winds and intense inversions that supresses vertical mixing, episodes of serve air pollution can occur (figure 2.11).

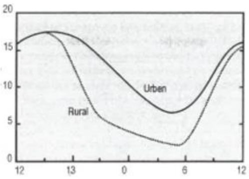


Figure 2.9

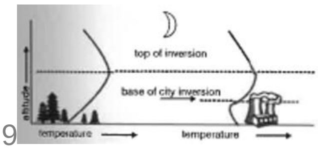


Figure 2.10

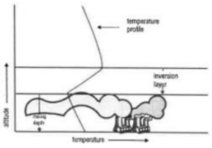


Figure 2.11

Pollution influences the climate of a city. The particles reflect solar radiation, leading to a decrease in the solar energy that reaches the surface. Some particles also serve a nuclei upon which water vapour condenses, even a 70% relative humidity, forming haze and increasing the frequency of city fog. Precipitation cloudiness may be greater in cities than in rural areas. This is due to the added nuclei and to the excess heat that reduces air stability and enhances vertical air motions. Thus, in an urban area, we expect to have higher levels of pollution than a rural area, higher values of temperature, precipitation, cloudiness and frequency of fog and lower values of solar energy reaching the surface, relative humidity, wind speed and visibility. Cities also influence the climate of areas that are downwind from them. The annual precipitation in such areas is increased as a result of the additional transport of particles or moisture emitted by industries close to this area.

1.8b Over population

There are a lot of factors that come into play in order to plan for future sustainability, starting from energy, water, land, and biological resources. But often, a very important factor is overlooked, that factor being the number of humans that have to share the consumption of these resources. The population of the world will be as twice as it is now from the current 6.5 billion in less 60 years, based on a growth rate of 1.2% per year (population reference Bureau 2005). Even if international policies of a couple of kids per household where implemented, the population of the world will not see a significant decrease in the growth rate for almost 70 years where it may stabilize at around 13 billion people. Cities are increasingly expanding their boundaries and population, and from the climatological point of view, human history is defined as the history of urbanization. The increase industrialization and urbanization of recent years have dramatically affected the number of the urban buildings, with major effects on the energy consumption of this sector. It's expected that 700 million people will have moved to urban areas during the final decade of the century. The number of urban dwellers rose from 600 million in 1950 to 2 billion in 1986 and, if this growth continues, more than half of the world's population will live in cities by the end of the century, whereas a hundred years ago, only 14% lived in cities and even in 1950, less than 30% of the world's population was urban. Current and projected urban populations, by region as reported by the United Nations, are given in figure 1.1. improving living standards, increase the space requirements per person. It is characteristic that in the USA, between 1950 and 1990, the floor space requirements person doubled. Very important variolisations in housing floor space per person also exist in Europe because of social and economic differences. Moscow has 11.6 m^2 net living space per person, while Paris has 28.2, Oslo 47.2 and Zurich 50.6 m2 per person. Today, at least 170 cities each have more than on e million inhabitants. It's estimated that, in the USA, 90% of the population will be living in, or around, urban areas by the year 2000, while other estimates show that urban populations will form 80% of the total world population in 2100. In Europe, more than 70% of the population is living in urban areas. Figure 1.2 shows the population growth of in European cities. In Africa, while in 1925 the population living in cities of more than 100,000 inhabitants was close to 500,000, this number increased to 20 million in 1972, and 72 million in 1988. Expansion of our cities means that more land is required to support them. According to Stunners and Bourdeau, in Europe, 2% of agricultural land is lost to urbanization every ten years. Hahn and Simonis report that, during the last century, the surface of urban land per capita in Europe has increased then times. It is characteristic than an average European city of one million inhabitants consumes every day 11,500 tonnes of fossil fuels, 320,000 tones of water and 2,000 tonnes of food. It produced also 300,000 tonnes of wastewater, 25,000 tonnes of CO_2 and 1,600 tonnes of waste. The direct and indirect needs for land are well represented by the notion of the ecological footprint, defined as the land required to feed a city, supply it with it with timber products and reabsorb its carbon dioxide emissions in areas covered with growing vegetation. This concept helps to set the limits to the activities that an area can absorb in a sustainable way. Based on the calculations of the sustainable London Trust, London's ecological footprint is close to 50 million acres, which is 125 times is actual surface area. Calculations by Wackernagel and Rees show that the mean ecological footprint in the world is close to 1.8 ha/person and, while in India it is close to 0.4, in Canada it is 4.3 and, in the USA, close to 5.1 ha/person. In addition to the above the increased urbanization associated with the loss of agricultural land, wilderness and green areas adds an important additional cost because new infrastructure has to be developed and the existing infrastructure in older parts of a city is used less and thus not well amortized. This is well supported by recent studies in the UK that show that in urban areas almost 60,000 hectares of land are vacant.

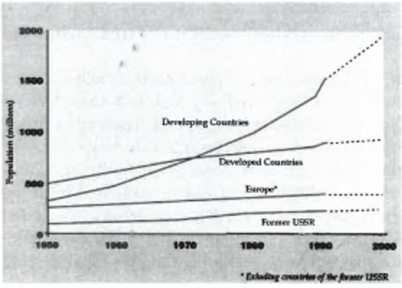


figure 1.1

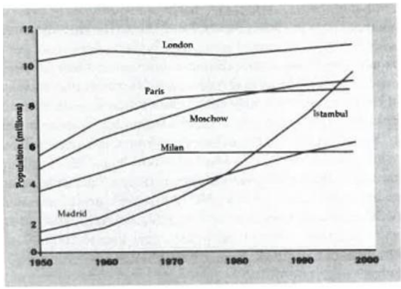


Figure 1.2

Chapter 2

This chapter focuses on examining the current trends of energy use and its impacts on the environment from a global perspective, in addition to the benefits and elements of the renewable energy. There will be an overview of different energy sources, production and consumption and then discusses the relationship between energy per capita and human, development as a mean of assessing the sustainable development. More importantly, the energy and carbon dioxide (CO_2) emission of building sector during the life cycle of buildings will be demonstrated in detail with the aid of carbon-accounting frameworks applied in construction. Various energy principles and technologies to improve building energy efficiency will also be proposed and discussed.

2 Energy sources, production, and consumption

Primary and secondary energy sources

The numerous energy sources used in the world can be categorised as primary and secondary energy sources. Primary energy sources are those that can be directly used, as they are naturally available. Some of the examples of primary energy sources are: Solar energy, which is responsible for solar thermal energy, hydropower, wind, photovoltaic energy as well as the production of biomass energy. Coal, oil, natural gas and wood sources. Geothermal energy, originated from molten core of the earth. Nuclear energy, originated from the nuclei of atoms. Tidal energy, originating from the gravitational attraction from the moon. Among the different primary energy sources, the sun's energy is the dominant source of energy on the earth. Figure 4.1 compares the global primary energy sources from 1973 to 2018 as a pie chart representing the fraction of each primary energy source. It can be seen that total primary energy sources increased from 6097 Mtoe to 13,972 Mtoe during the past four decades (IEA, 2019). Also, the renewable energy sources including biofuels are waste, hydro, nuclear and other energies have increased from 13.2% to 18.7%.Primary energy sources can be divided into renewable energy sources and non-renewable energy sources. Renewable energy sources are produced from geophysical or biological sources that are naturally replenished at the rate of extraction. For example, photovoltaic solar energy, wind energy, tidal energy, hydropower, etc. are renewable energy sources. The development of renewable energy has been advocated to reduce greenhouse gas (GHG)emission and mitigate climate change impacts, while it would also be a solution coping with the problem of peaking in oil supply. On the other hand, non-renewable energy sources, such as fossil fuels (coal, oil and natural gas), are characterised by long regeneration times with the extraction rates much higher than the replenishment rates. For example, fossil fuels took million years to form, and although still plenty of those sources are available, they are limited by increasing extraction rate and have a finite lifetime. the nuclear energy is generated by a controlled fission process of uranium-235 in nuclear reactor to heat the water (270degree C) into steam that drives electricity generator. It has been reported that the nuclear energy is not strictly a renewable energy sources because the uranium reserves are also finite. The secondary energy sources are derived from the transformation of primary energy sources. For example, electrical energy that is derived from the conversion of mechanical energy, chemical energy or nuclear energy and petrol that is derived from the processing of crude oil are known as secondary energy sources. It must be underlined that the transformation of primary to secondary energy sources leads to an energy loss of up to 30%.

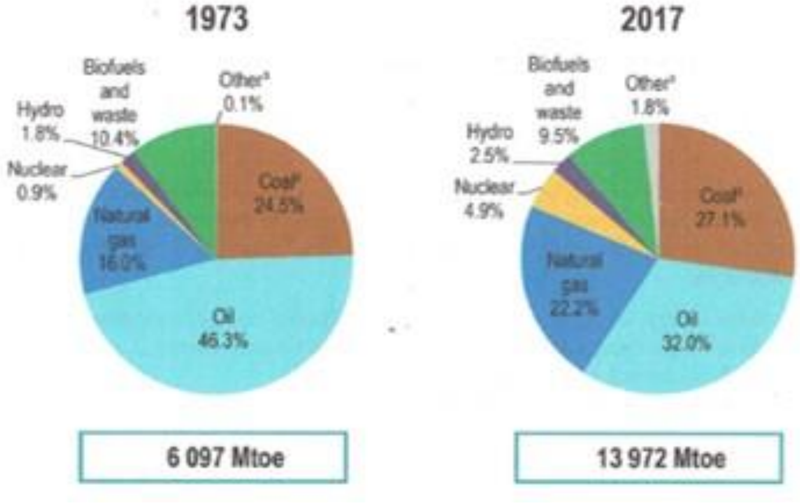


Figure 4.1

2.1 The Energy Consumption

The energy production and consumption as a means of available reserve are given in table 4.1 the unit is million tonnes for oil and coal and billion cubic metre for natural gasses. The trend of world energy consumption is also plotted in Figure. 4.2. global energy consumption increased 2.9% in 2018. Growth was the strongest since 2010 and almost doubled the 10-year average. The demand for all fuels increased, but growth was particularly strong in the case of gas (168 Mtoe, accounting for 43% of the global increase) and renewables (71 Mtoe, 18% of the global increase). The production and consumption of fossil fuels, hydroelectric energy, and renewable energy are presented in table 4.2 the share indicates the percentage of total production or consumption in the world. The higher consumption than production of oil implies that about 72% of consumption in 2018 was derived from import.

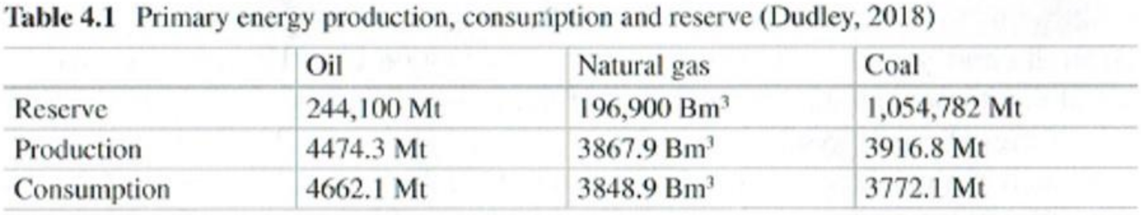


Table 4.1 Primary energy production, consumption and reserve (Dudley, 2018)

	Oil	Natural gas	Coal
Reserve	244,100 Mt	196,900 Bm^3	1,054,782 Mt
Production	4474.3 Mt	3867.9 Bm^3	3916.8 Mt
Consumption	4662.1 Mt	3848.9 Bm^3	3772.1 Mt

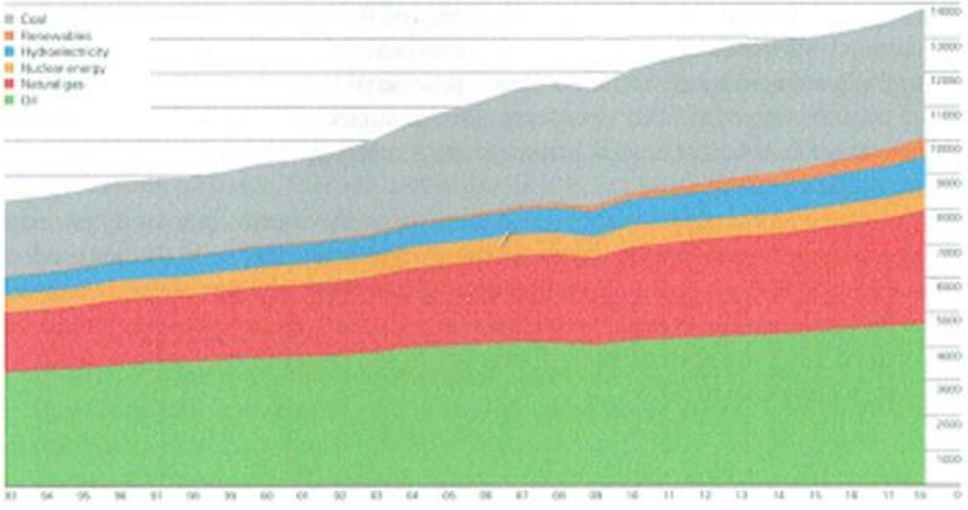


Figure 4.2

Table 4.2 Energy production and consumption in Australia (Government, 2019)

	Production		Consumption	
	Quantity	Share	Quantity	Share
Oil	15.2 Mt	0.3%	53.4 Mt	1.1%
Natural gas	130.1 Bm^3	3.4%	41.4 Bm^3	1.1%
Coal	301.1 Mt	7.7%	44.3 Mt	1.2%
Hydroelectric energy	–	–	3.9 Mt	0.4%
Other renewables	–	–	7.2 Mt	1.2%

2.2 The Energy Impact of the urban environment

Urban environment and the energy consumption of buildings

Today, it is well accepted that urbanization leads to a very high increase of energy use. Data on the energy and specific electricity consumption of major European cities are given by Eurostat. Data on the electricity consumption in European range from 60 GWh/year for Valetta to 26,452 GWh/year for London. The average electricity consumption calculated on the basis of available data for cities with more than a million inhabitants is around 4500 GWh per year, however, these data cannot used to draw and conclusion.

Other, statistical, data show that the amount of energy consumed by cities for heating and cooling of offices and residential buildings in western and southern Europe has increased significantly in the last two decades. A recent analysis showed that a 1% increase in the per capita GNP leads to an almost equal (1.03%) increase in energy consumption.

However, as reported, an increase of the urban population by 1% increases the energy consumption by 2.2%, the rate of change in energy use is twice the rate of change in urbanization. These data show clearly the impact that urbanization may have on energy use.

Increased urban temperatures have a direct effect on the energy consumption of buildings during the summer and winter periods. In fact, it is found that during summer, higher urban temperatures increase the electricity demand for cooling and the production of carbon dioxide and other pollutants, while higher temperatures may reduce the heating load of buildings during the winter period. In parallel, the wind and the temperature regime in canyons dramatically affect the potential for natural ventilation of urban buildings and thus the possibility of using passive cooling techniques instead of air conditioning.

Analysis of existing data correlating urban temperatures and energy consumption

Unfortunately, very few studies have been carried out on the impact of the urban climate on the energy consumption of urban buildings of heating and cooling purposes.

Existing studies either correlate increased urban temperatures and the corresponding electricity demand for selected utility districts or use sets of local temperature data to calculate the breakdown of the cooling and heating load in a city suffering from increased temperatures.

Both mythologies and techniques have important advantages. When correlations between temperatures and energy use are established by relating utility-wide electricity loads to temperatures at the same time of the day, a very clear picture of the real impact of high urban temperatures is established.

However, to achieve this, it is necessary to minimize the effects on the electricity demand that are not climate related, which is not possible: and when it is possible, it may not always be accurate.

Although this technique gives an estimation of the increase in the energy consumption in an integrated way, it does not permit the investigation of local effects and the impact of the specific urban layout and characteristics on the energy consumption of the buildings. Two specific studies that make use of the two techniques are presented.

First, the increase summer electricity load of some American cities, calculated mainly from utility data, and in Greece during the period 1996-1999 almost 30 temperature and humidity stations have been installed in and around Athens measuring ambient temperature and humidity on an hourly basis since June 1996.

2.3 Energy per Capita and Human Development

In 2019, top then nations of energy consumers are China, the United States, India, Russia, Japan, Canada, Germany, Brazil, South Korea and Iran.

Australia is at the 17th position. The top ten nations energy use per capita in given in (table 4.3), and Australia is ranked at the 13th position. To some extent, energy use per capita is an appropriate indicator related to sustainable development (table 4.3) shows the energy consumption per capita in 2019.

It is interesting that there is no correlation between energy consumption and standard of living.

Japan and western Europe have high standard of living comparable with (or may be even better than) that of the United States, Canada and Australia and yet have far lower energy consumption rate. However, it must be noted that these countries export some of the energy in terms of either products or manufactured goods to other countries. United nations development programme (UNDP) Human Development Report (UNDP,2007) found that human development index (HDI), which reflected several key social aspects related to sustainable development, including healthy life, knowledge or education and living standard, is correlated with the energy consumption per capita (tonnes of oil equivalent per capita).

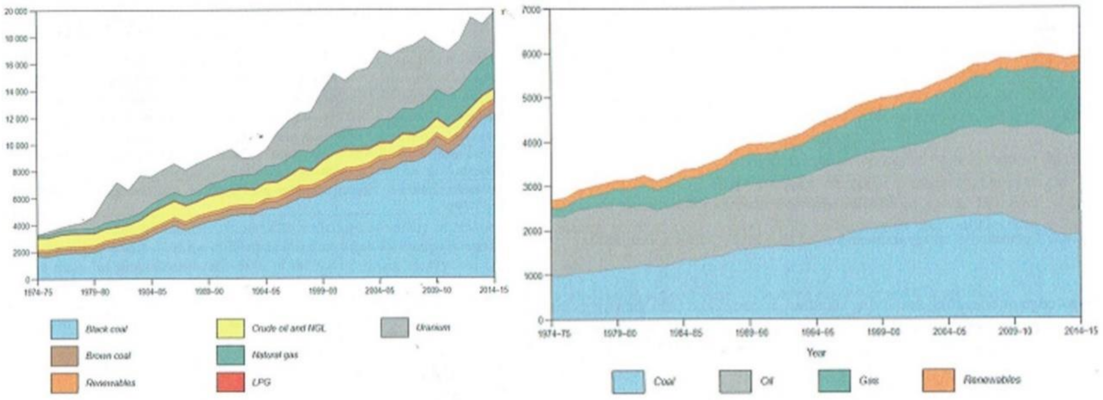
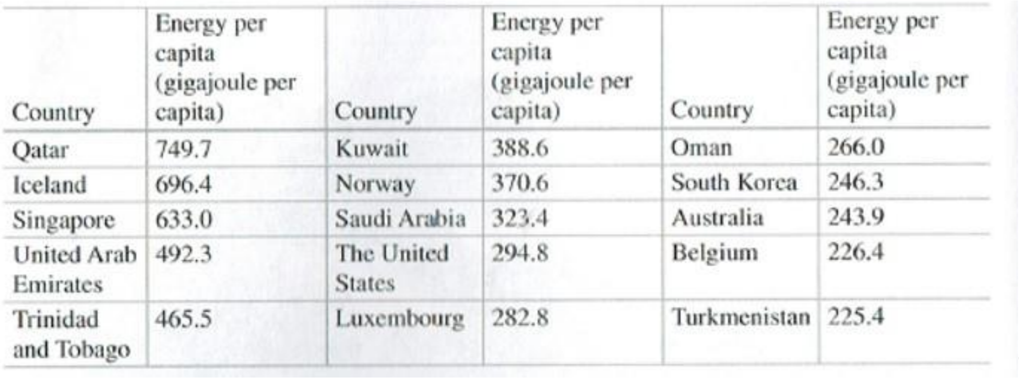


Figure 4.3/Figure 4.4



Country	Energy per capita (gigajoule per capita)	Country	Energy per capita (gigajoule per capita)	Country	Energy per capita (gigajoule per capita)
Qatar	749.7	Kuwait	388.6	Oman	266.0
Iceland	696.4	Norway	370.6	South Korea	246.3
Singapore	633.0	Saudi Arabia	323.4	Australia	243.9
United Arab Emirates	492.3	The United States	294.8	Belgium	226.4
Trinidad and Tobago	465.5	Luxembourg	282.8	Turkmenistan	225.4

Table 4.3

2.4 Energy and CO2 Emission of Construction Sector

As reported by Intergovernmental Panel on Climate Change (Solomon 2007). Direct emission from the building sector (excluding emissions from electricity use) was about 5 Gt CO_2 equivalent (CO_2-eq) in 2004. It reached 8.6 Gt when indirect emission from electricity use was considered. It is almost a quarter of the total global emission. The Australian Greenhouse Office has sponsored various studies to provide projected levels of energy consumption and Greenhouse gas emissions for the Australian residential and nonresidential building sectors. A study on the energy consumption and CO2 emissions of variety of buildings from cradle to grave with 50 years of lifespan has found that the energy consumption from these buildings is about 80-90% of the total primary energy and CO2 emission. Whereas the remaining 10/% is a result of embodied energy and demolition.

Reduction of CO_2 emission can be implemented by the following measures: Reduce embodied energy in buildings, which is directed to the energy consumption in the manufacturing and transport of building materials and products.

Reduce energy consumption, for example, via energy efficiency. It is directly related to energy demand for buildings operation, known as operating energy. Switch to low-carbon building construction and operation process, for example, through the use of renewable energy and low-carbon fuels. Considering that the majority of CO2 emission is related to building use rather than manufacturing, maintenance and demolition, building energy efficiency would be the most -effective way to reduce GHG emission of buildings. It should be mentioned that sustainable development may provide many options for GHG emission reduction, while sustainability embraces more broad domains, not only in environment, but also on social and economic aspect. It is understood that reduction of GHG emission could be achieved in building sector.

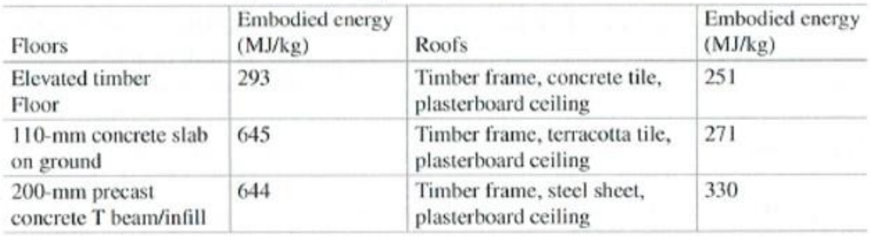
Which is not only a benefit to the aversion of climate change. But also the achievement of sustainable development and economic goals. However, it may require strong push at policy level. Both technologies and policies that address integrated solutions for mitigation are important for the sustainable development under climate change.

2.5 Embodied Energy

Embodied energy is the energy consumed by all of the processes associated with the production and supply of buildings materials, components and structures and the construction of buildings. The energy embodied in the existing building stock in Australia is equivalent to about 10 years of the total energy consumption for the entire nation. Table 4.5 gives the embodied energy of some typical building materials.

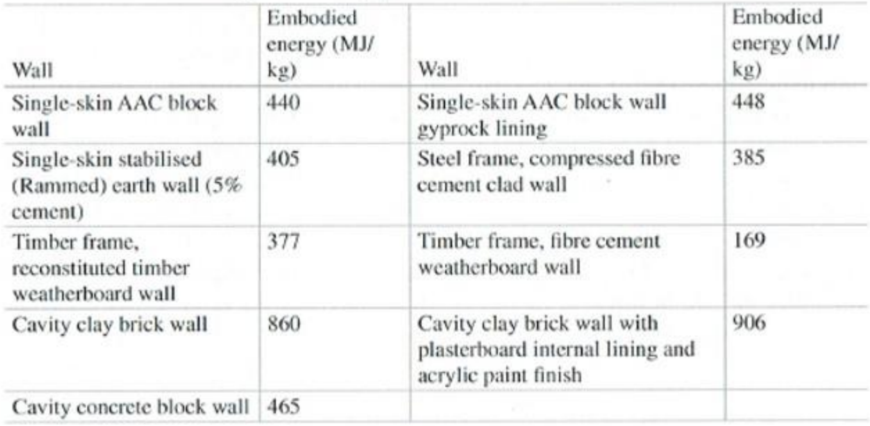
CO_2 emissions are highly correlated with the energy consumed in manufacturing building materials. As seen from table 4.5, the embodied energy per unit mass of materials used in building construction can be enormously different, from about 0.5 MJ/KG for air-dried sawn hardwood to 170 MJ/kg for aluminium. Apart from the embodied energy, other factors also affect environmental impact of materials, such as the variation in quantity of materials to perform same task, differing lifetimes of materials leading to intermediate replacements and different design requirements. For example, when comparing the brick veneer and fibre cement sheets as exterior walls for dwellings, bricks have high embodied energy and no structural role while they do not require a replacement; fibre cement sheets have lower embodied energy with similar structural and thermal performance, however, intermediate replacement is required during the lifespan of the building.

Table 4.6 Embodied energy of assembly process of floors and roofs (Milne & Reardon, 2013)

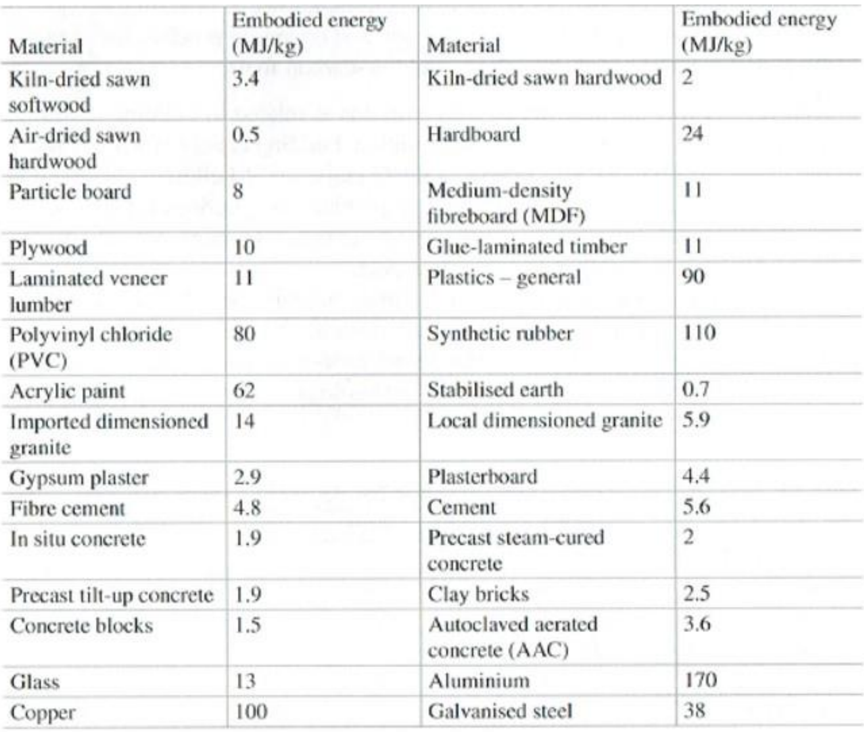


Floors	Embodied energy (MJ/kg)	Roofs	Embodied energy (MJ/kg)
Elevated timber Floor	293	Timber frame, concrete tile, plasterboard ceiling	251
110-mm concrete slab on ground	645	Timber frame, terracotta tile, plasterboard ceiling	271
200-mm precast concrete T beam/infill	644	Timber frame, steel sheet, plasterboard ceiling	330

Table 4.7 Embodied energy of assembly process of walls (Milne & Reardon, 2013)



Wall	Embodied energy (MJ/kg)	Wall	Embodied energy (MJ/kg)
Single-skin AAC block wall	440	Single-skin AAC block wall gyprock lining	448
Single-skin stabilised (Rammed) earth wall (5% cement)	405	Steel frame, compressed fibre cement clad wall	385
Timber frame, reconstituted timber weatherboard wall	377	Timber frame, fibre cement weatherboard wall	169
Cavity clay brick wall	860	Cavity clay brick wall with plasterboard internal lining and acrylic paint finish	906
Cavity concrete block wall	465		



Material	Embodied energy (MJ/kg)	Material	Embodied energy (MJ/kg)
Kiln-dried sawn softwood	3.4	Kiln-dried sawn hardwood	2
Air-dried sawn hardwood	0.5	Hardboard	24
Particle board	8	Medium-density fibreboard (MDF)	11
Plywood	10	Glue-laminated timber	11
Laminated veneer lumber	11	Plastics – general	90
Polyvinyl chloride (PVC)	80	Synthetic rubber	110
Acrylic paint	62	Stabilised earth	0.7
Imported dimensioned granite	14	Local dimensioned granite	5.9
Gypsum plaster	2.9	Plasterboard	4.4
Fibre cement	4.8	Cement	5.6
In situ concrete	1.9	Precast steam-cured concrete	2
Precast tilt-up concrete	1.9	Clay bricks	2.5
Concrete blocks	1.5	Autoclaved aerated concrete (AAC)	3.6
Glass	13	Aluminium	170
Copper	100	Galvanised steel	38

Table 4.5

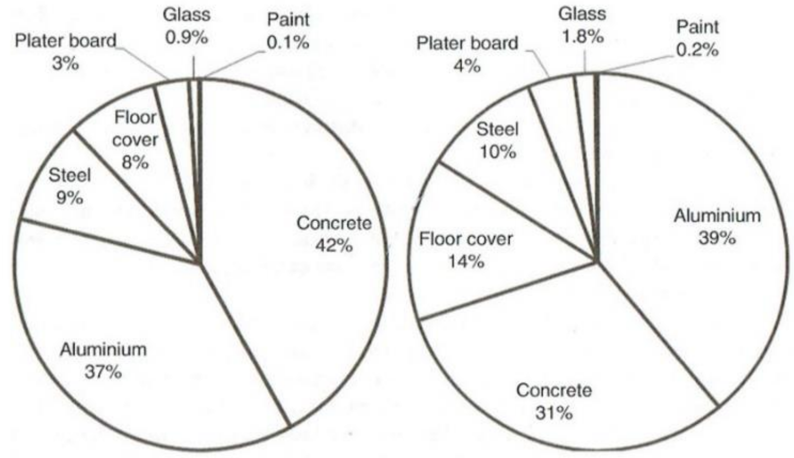


Figure 4.6

Materials such as concrete and timber have the lowest embodied energy intensities but are consumed in very large quantities. On the other hand, steel has high embodied energy, however, it is consumed in much smaller quantities (Attia, 2018). Table 4.6 and 4.7 give the embodied energy produced during assembly process of floors, roofs and walls. There has been little change in materials supply and selection in the last 20 years or so, so there has been little change in embodied energy consumption in dwelling per unit area (about 5 GJ/m2). However, there is an increase in floor area per dwelling by about 20% with a corresponding increase in embodied energy (committee, 2001; Treloar & Fay, 2005). Embodied energy represents 20-50 times the annual operational energy of most Australian buildings (Treloar & Fay, 2005). Reuse of building materials could save from 20% (Glass) to 95% (aluminium) of the embodied energy (Kumar 2020). Thus, in order to save on embodied energy, one can encourage smaller size dwellings (a planning issue) and the reuse of building materials (a building code issue). In estimating the amount of embodied energy associated with a building, it is necessary to count the energy associated with the production, transportation and construction stages. Figure 4.6 shows the GHG emission of production of construction materials and percentage of total embodied energy in typical Australian buildings it can be seen that concrete has the highest share of the GHG emission, followed by aluminium, floor cover and steel. However, in the case of embodied energy, aluminium has the highest embodied energy followed by concrete. This is because the production of aluminium requires very high amount of energy than the production of concrete (about 200 times), and GHG emission is 19 times higher than concrete production (Bisway, 2014).

In estimating the effectiveness of recycled materials, it is necessary to compare the embodied energy of the virgin and recycled materials since some recycled materials require more energy to reprocess than virgin materials. Reducing heavyweight construction systems that use masonry and adopting lightweight construction that uses timber or light gauge steel framing to support non-structural components, may reduce the embodied energy. If the economics of material production and delivery is not distorted by other factors, there should be a close correlation between the cost of a building material or component and its embodied energy. Thus, by trying to obtain a minimum cost solution, the designer may also achieve a most efficient embodied energy solution, it should be mentioned that the selection of materials with low embodied energy may have a negative impact on building thermal performance, which subsequently leads to more energy consumption for heating, ventilation and air conditioning (HVAC), which should actually be considered over the whole service life cycle of buildings.

2.5.1 Energy efficiency in buildings

A buildings system can be considered as a complex thermodynamic system, subjected to internal and external thermal solicitations, with the building's envelope as the boundary of the system. The energy efficiency of buildings should include the efficiency aspects in the following's elements:

The building envelope – both conduction and solar transmission aspects The lighting system / the heating and cooling system / the ventilation system/ the hot water supply system / the building elevators.

The Japanese system also includes other factors such as:

Direct use of natural energy (natural light and ventilation) / use of renewable energy (solar panel) / other measures for improving energy efficiency (use of unused heat, monitoring system, operational management system) .

2.5.2 Efficiency Principles

There are many efficiency principles to increase energy efficiency and to reduce GHG emission. Some of the efficiency and principles are given below:

Reduce heating, cooling and lighting load by optimisation of insulation, glazing, airtightness, thermal load shifting (for example, store energy during daytime and heating space during night through thermal energy harvest system).

Actively utilise solar, wind and other renewable energy, create heat source or sink. Passive building design has been widely advocated to increase energy efficiency. Increase efficiency of appliances and HVAC equipment.

Develop incentives and enhance awareness to change energy use behaviour. Apply systematic and holistic approach in design and management by considering energy use over time instead of a steady time, and over all end uses in the building space instead of individual appliances.

Consider building form, orientation, shading and related attributes.

2.5.3 Carbon accounting in construction

Carbon account is becoming an increasingly important issue when there is a growing demand from regulations and obligations in reporting greenhouse gas emission.

Scope 1: it concerns emission released from a facility as a direct result of the activities of the facilities, and determined by (energy, 2017). Fuel combustion/ Fugitive emission: mainly released from extraction, production, processing and distribution of fossil fuels. Industrial process emission: released from the consumption of carbonates and the use of fuels as feedstocks or as carbon reductants. Waste emission: released from landfill and wastewater treatment.

Scope 2: It concerns emissions in a form of indirect emission that occurs principally at electricity generators as a result of electricity consumption at another facility.

In general, there are four methods to measure emissions (energy, 2017) in terms of example Australia.

Using national greenhouse accounts, which is the default method used by Australian Department of climate change and Energy Efficiency and is within the international guidelines adopted by the United Nations Framework convention on Climate Change for the estimation of greenhouse gas.

A facility-specific method, using industrial sampling and Australian or international standards or equivalent for the analysis of fuels and raw materials to provide more accurate estimation of emissions.

A facility-specific method, using Australian and international standards or equivalent for both sampling and analysis of fuels ad raw materials.

Direct monitoring of emission systems, either continuous or a periodic basis.

For sustainable buildings and construction, method I will be discussed. Fundamentally, it specifies the use of designed emission factors, for example, in terms of kilogram of $CO_{2\text{-eq}}$ per kilojoules of energy use, in the estimations. The emission factors are national average factor determined by Australian Emissions Information Systems. For Scope 2, emission factors are updated annually to reflect the latest information on the mix of electricity generation sources. The more use of renewable energy leads to low emission factors. The following gives the details of estimation of emissions based on Method 1.

Emission from Fuel Combustion

Emission from fuel combustion is estimated by,

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ij}}{1000} \mathrm{CO_2 - e\ tonnes}$$

Where E_{ij} is the emission of gas type (j) from each fuel type (i) in CO2-eq tonnes, Q_i is the quantity of fuel type ($_i$) combusted in operation of the facility during the year, EC_i is the energy content factor of fuel ($_i$), and EF_{ij} is the emission factor for emission gas type $_{(j)}$ released from the combustion of fuel ($_i$).

Emission from Fuel Electricity

Scope 2 emission or emission from electricity is estimated by:

$$Y = Q \times EF / 1000$$

Where Y is the scope 2 emissions measured in $CO_{2\text{- eq}}$ tonnes. Q is the quantity of electricity purchased from the electivity grid during the year and consumed from the operation of the facility measured in kilowatt hours (1 GH=278KWh). EF is the Scope 2 emission factors, in kilograms of $CO_{\text{-eq}}$ emission per kilowatt hour.

the Scope 2 emission factors, are assigned as state-based emission scenario because the electricity production methods and production efficiency differ in each state of Australia. The emission factors also consider the interstate electricity flows between states.

Energy and carbon emissions are the commonly used metrics to quantitatively assess the sustainable development in built environment. Buildings and infrastructure are expected to last 50-200 years, and the efficient use of energy as well as the emission reduction during the life cycle is crucial to achieve sustainable development.

2.6 Renewable Energy

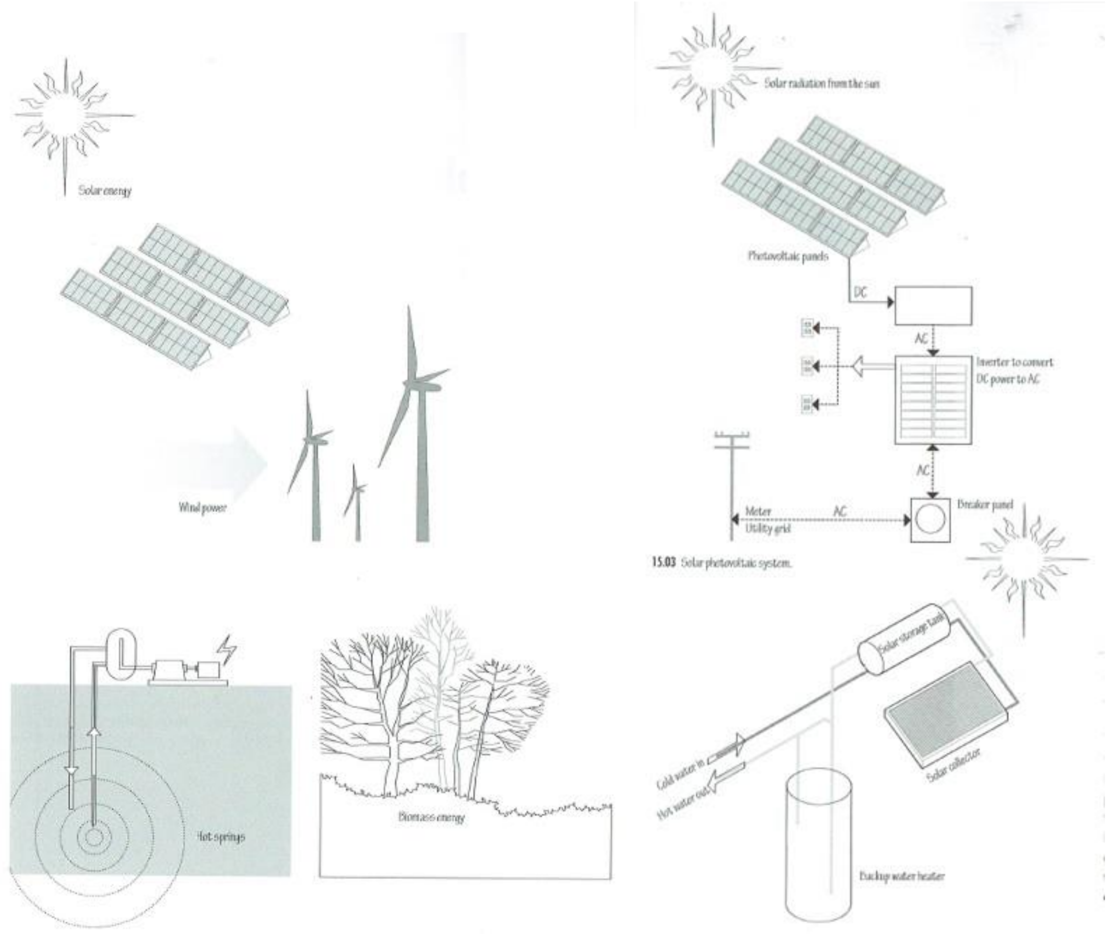
Renewable energy is energy that is provided by renewable sources, such as the sun or the wind. Renewable energy is contrasted with energy generated by fuels that are subject to depletion, such as oil, natural gas, and coal, which were formed over millions of years and that society is consuming at a rate faster than the rate at which the fuels where formed.

Renewable energy is also contrasted with the energy generated by fuels that create pollution that will have a lasting effect, such as nuclear energy. Having designed a low- energy building, attention can now be directed to renewable energy to provide some or all of the remaining energy needs of the building.

At this juncture in design from the outside in, the building should be receptive to renewable energy equipment because of prior attention to receptivity, as in roof or site design. For example, the roof has been oriented to maximize solar radiation and obstructions have been removed to maximize the area available for solar panels.

The renewable systems considered here are primarily solar and wind. The use of biomass for heating is sometimes considered to be a renewable energy., “Heating and Cooling”. Ground source heat pumps are sometimes described as a renewable energy technology, but this is a misnomer.

Ground source heat from hot spring might validly be considered renewable, whereas ground source heat pumps rely on electricity just as other types of heat pumps do and therefore cannot be considered renewable.



15.03 Solar photovoltaic system.

2.6.1 Solar Energy

Solar energy can be used to generate electricity through solar photovoltaic (PV) systems or to generate heat using solar thermal systems.

2.6.2 Solar Photovoltaic Systems

Solar photovoltaic panels are commonly referred to as modules. Photovoltaic systems have no moving parts. Electric power is generated in the modules in the form of direct current (DC) power. A control device called an inverter takes this DC power and converts it into the alternating current (AC) power required in buildings. The energy generated by solar photovoltaic systems can alternately be fed back to the electric grid if more power is generated than is needed in the buildings.

A photovoltaic system can either be connected to the electric grid (grid-tied) or use batteries to serve as a stand-alone system, or both, to allow the system to both connect to the grid but to operate on its own in case of a power outage. Most current systems are grid-tied, although batteries are preferred by those who value self-reliance. Benefits of solar photovoltaic systems include a mature and reliable technology and predictability in the amount of electricity that can be generated.

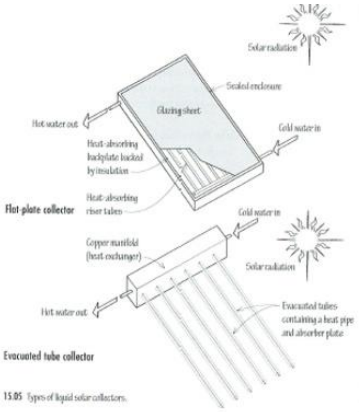
The use of solar photovoltaic energy has grown significantly as a result of dropping prices, government incentives, public interest, and new financing options. Reliability risks include damage to modules and problems with inverters, but these risks are generally low.

2.6.3 Solar Thermal Systems

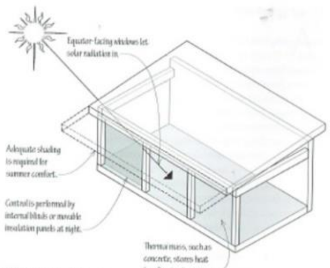
Solar thermal systems can either be used the heat a liquid or to heat air. Solar thermal panels are commonly referred to as collectors.
The liquids used in solar thermal systems are either water in warmer climates or a water-antifreeze mix in cold climates. Liquid systems can either be passive, operating without a pump, or active, requiring a pump, passive systems are referred to as thermos-siphon systems in which case the storage thank is located at the high point of the system, typically above the collectors on a roof, to allow water to circulate by gravity.

These water-based thermos-siphon systems are more common in warm climates where there is no risk of freezing. Common liquid collector types include flat-plate collectors and evacuated tube collectors. Flat-plate collectors are lower in cost but are also generally lower in efficiency. Evacuated tube collectors are higher in cost but higher in efficiency and can be easier to install on a roof because the collector is field assembled from modular tubes. Air-based systems can either heat outdoor air that is being drawn in for ventilation or heat indoor air. The ventilation application is common in a type of collector known as a transpired solar collector, where the air is drawn in through hotels in the collector. Systems that heat air can be considered active, using a fan to circulate air, or passive, operating without a fan. Whether active or passive, solar thermal systems typically have three components: Collection, to receive the sun energy. Storage, to store heat from periods when the sun is available and deliver it when the sun is not available.
Controls, to initiate collection and storage of solar energy when it is available and to prevent losses when the sun is not shining.

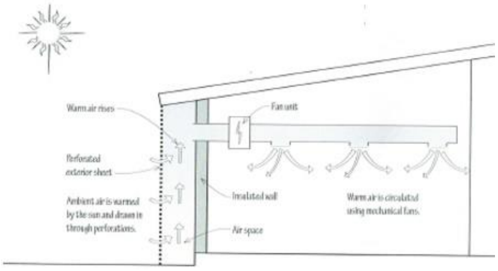
These three components are important for the effectiveness of a solar thermal system. Without the three components, a solar thermal system may lose more heat than it gains, as collectors can lose energy as easily to the night sky as they can gain energy from the daytime sun, if not correctly collected, stored, and controlled.

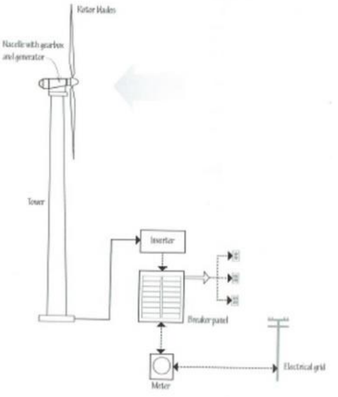


15.05 Types of liquid solar collectors.



15.07 Passive solar energy system.





2.6.4 Passive Solar Energy

Passive solar energy refers to the harvesting of solar heat without the use of mechanical or electrical systems, such as pumps or fans. The passive solar energy field in many ways laid the groundwork for much of our current knowledge both in building efficiency and in solar energy. Through hard-earned experience in developing passive solar system, we have learned how passive-heated buildings need the three elements of solar energy system, including collection, storage, and control. Collection is performed by south-facing windows. Storage is typically performed by thermal mass.

Control is performed by such devices as movable insulation for windows at night. We now know that large equator-facing windows without both storage and control will overheat a building during the day and cause losses at night that require added and unnecessary fossil fuel energy use. Passive solar remains a viable option for those who are committed to buildings energy systems with few moving parts, who are willing to accept imperfections such as indoor temperature fluctuations, and who are willing to actively engage in the control of their energy system, as for example, by placing and removing insulation or thermal shades on windows at night.

2.6.5 Wind Energy

Modern wind turbines are used to generate electricity. An advantage of wind turbines over solar photovoltaic systems is the potential to generate power during both day and night. Disadvantages include high cost, dependence on steady winds, and noise pollution. Like solar photovoltaic systems, wind turbines can be grid tied or stand- alone systems, wind batteries, or both. Wind turbines are available in a wide variety of sizes-small enough to power a single home or large enough to serve as a power plant with several turbines typically grouped in a wind farm.

Wind turbines are best located high off the ground, typically at the top of dedicated wind towers, to reach where the wind blows steadily. Building-mounted wind turbines are available but are low in both efficiency and capacity. As with solar photovoltaic, system, wind power systems typically generate direct (DC) power and use an inverter to convert this power to alternating current 9AC). Wind system design begins by evaluating whether wind conditions are sufficient. Online tools that map typical wind conditions at a site include those provided by the National Renewable Energy Lab or by private companies.

A fundamental variable to consider in the use of wind turbines is wind velocity. If the wind velocity doubles, eight times the energy is available. Therefore, small changes in wind velocity produce significant changes in delivered wind energy. Wind energy is most viable for areas with average wind velocities over 16 miles per hour (26km/h) at a height of 160 feet (48m) above ground level. Another rule of thumb is that wind velocities at ground level need to be between 7 to 9 miles per hour (11 and 14 km/h).

Wind towers should be far enough from a building to avoid noise and vibration issues but close enough to avoid high costs in routing wiring from the tower to the building. The impact of the building itself on wind patterns needs to be considered. A hill near a building is a good location. Towers should be as tall as local zoning ordinances allow.

The higher the tower, the stronger and less turbulent is the wind. Wind turbines should preferably not be mounted on or to buildings. The wind close to a building tends to be turbulent and weak. Turbines mounted near the ground tend to be highly ineffective, A rule of thumb is that the bottoms of wind turbine rotor blades need to be a minimum of 30 feet (9m) above any obstacle within 300 feet (91m).

Concerns about wind power include bird and bat fatalities, although such fatalities are estimated to be significantly fewer than those from power lines, communication towers, and buildings themselves.

2.6.6 Solar Photovoltaic Energy for different climates

Solar photovoltaic energy has emerged as the primary source of renewable energy for green buildings. Figure 15.11 shows available solar energy in different locations around the world. The illustration should only be used for preliminary estimates. Final design should always be based on calculations with local conditions.

We no longer view any specific geographic locations as having inadequate solar energy. Such as a site being considered to be “too cloudy”.

For example, Germany has the largest installed solar capacity in the world even though it is on the lower end of the available solar energy spectrum. Japan, number two in the world for installed capacity, also does not have high available solar energy.

In the U.S., new jersey and Massachusetts, two small states with relatively little available solar energy, have among the highest installed solar photovoltaic capacity of any states.

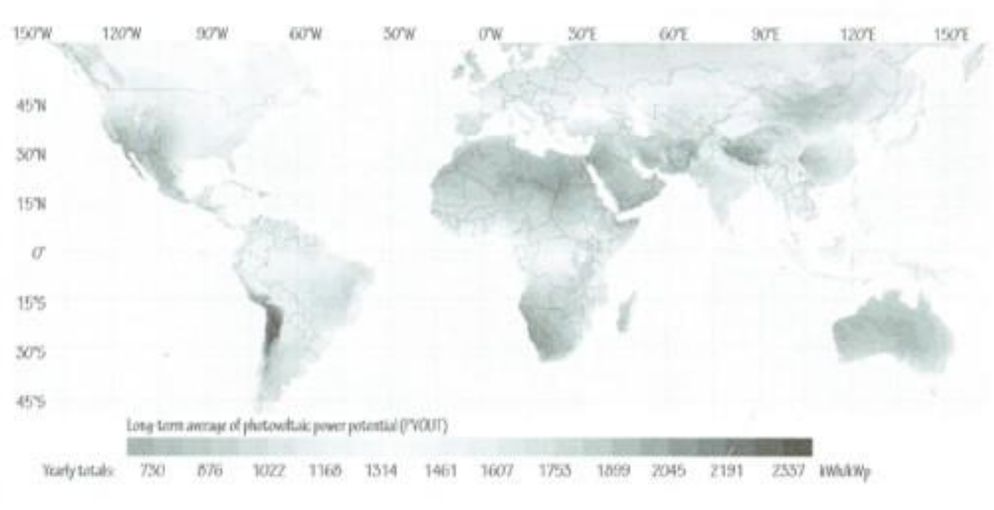


Figure 15.11

2.7 Building – Scale Energy Storage

Purposes of energy storage include:

To match electric loads to renewable generation. For example, as we increasingly use heat pumps that use electricity for heating.

The peak time for heating is at night, but solar energy is generated during the day. We have less control over when and how much renewable energy (hydro, solar, Wind) is produced, so energy storage could help match load to generation.

To avoid use of electric generation with fossil fuels, and its associated carbon emissions.

To control costs for building owners, by avoiding peak demand electric charges, and by maximizing renewable energy that is generated on -site being used on-site.

To control costs for electric power generation by avoiding added electric generating capacity that is only used at times of peak demand.

To allow through zero- energy building operation without relying on the grid to absorb excess on-site renewably generated electricity and to supply electricity when on-site generated electricity is insufficient.

To improve the resilience of buildings, such as the ability to get through times of electric power outage.it should be noted that the different purposes of energy storage mean different amounts of optimal storage.

For example, the amount of energy required to get through a short power outage or peak electric power event is very different from the energy required to get through several days of cloudy weather to meet on-site energy needs when a solar energy system does not have adequate sun.

Obstacles to energy are primarily high cost, and so market penetration has been low, even in green buildings. Further, the ability of the electric grid to thus far fully absorb excess renewable energy has also worked against installing energy storage.

But this will end as renewable energy capacity increases. Some countries and regions already are producing excess renewable energy.

Between an increased demand for and decreasing costs of energy storage, it is likely that it will become a bigger part of green buildings.

Technologies for energy storage include batteries, thermal storage (two-phase change materials; single-phase materials, such as water), mechanical storage (pumped water, compressed air, flywheels etc.), and thermos-chemical storage.

Energy storage can be on either side of the electric meter-on the building side or on the utility side.

Energy storage is an emerging technology. It is not common yet, even though we have seen activity for several decades with modest market penetration, such a using ice storage for air conditioning in large buildings.

Energy storage is a next frontier in green buildings. The success of batteries in electric and hybrid vehicles points to the potential.

However, needs in vehicles (light, weight, compact, light – density) are different than needs in buildings (low cost, high total capacity), so we cannot assume that the approaches used in vehicles will succeed in buildings.

Chapter 3

3 Guidelines for integrating energy conservation techniques in urban buildings.

3.1 Energy strategies in urban buildings

The implementation of energy saving strategies in all categories of buildings residential, offices, shopping centres, hospitals or schools, either new or existing in an urban environment appears to be serious problem, the solution of which demands careful management. This difficulty is caused by the current condition of the urban fabric of cities, with respect to their planning and their frequently chaotic expansion, which has taken place without taking into account the principle of energy conscious design on an urban scale. Some of the factors that usually have a negative effect on the design and construction of urban buildings of low energy consumption are:

The layout of the basic road network with a specific orientation. This layout affects the siting of the buildings on either side of the road, giving them an orientation that, in most cases, is not suitable for the implementation of solar and energy-saving techniques.

The relationship between the height of the building and the width of the road, which causes overshadowing and thus prevents access to direct sunlight in living spaces.

The relationship between plot frontage and depth, which can determine how many internal spaces will have a southern aspect.

Densely built urban centres, which result in the obstruction of the airflow and of sunlight by the walls of tall buildings.

The lack of greenery, which has been replaced by concrete and tarmac.

The overshadowing caused by adjacent buildings and other landscape features, which is difficult to avoid.

Building regulations and codes that in most cases determine the dimensions of a buildings and thus its geometrical form and its position on the plot. Example in Thessaloniki are shown in Figure 16.1 to 16.3.

Figure 16.1

Figure 16.3

In spite of all negative aspects of the urban environment and its buildings, there are still many possibilities for energy-saving intervention, which also mitigate the greenhouse effect, filter pollutants and mask noise. These interventions, which are the building and then move on to the implementation of energy-saving measures. Furthermore, it must be noted that urban centres present milder climatic conditions than suburban or rural cities (higher temperature, les intensive winds) as a result of the heat-island effect. So, in spite of the negative effects of the above-mentioned factors, in particular of the difficulties that are encountered in the widespread implementation of bioclimatic architecture in urban buildings, the mild urban microclimate compensates in the winter period for the negative elements (inappropriate orientation, high density, shading, etc.). if we intervene correctly in the design layout, better climatic conditions will be achieved not only in the winter but, especially, during the summer, when serious overheating problems can occur in hot climates.

A large number of air-conditioning appliances ae used, especially in the southern urban areas, to solve the problems created by the improper energy design of buildings. This unfortunately leads to increased cooling loads during the summer and to overconsumption of electric energy, which also increases peak energy demand and creates failures and black-outs in the energy transport network. These strategies lead to an artificial, isolated, and mechanically controlled indoor environment, which is obviously inhospitable for the residents.

3.2 Solar architecture or energy-conscious design in urban buildings

In recent years there has been much talk of the need to save energy in the building sector by using simple and financially expedient methods that generally utilize conventional building materials. During this period, in which numerous researchers have concerned themselves with energy issues, various terms have made their appearance, such as ‘passive solar design’, ‘bioclimatic’ or ‘solar architecture’, ‘rational use of energy’, ‘energy-conscious design’ etc., which describe a tendency, a philosophy or a method relating to architecture and building practice. In reality, however, over and above their conceptual difference, all these terms have the following in common: they relate to a type of architecture that respects the environment and applies various methods and techniques to reduce the amount of energy consumed in heating, cooling, lighting or hot-water use, provided of course that these do not affect the thermal comfort conditions in the interior of the building concerned.

A key role in the effort to achieve this, if one isolates the ‘building’ from the built environment of which it forms part, is played by the building’s shell, because it forms a ‘filter’ between the external and internal environments. Thus, the majority of energy-saving interventions are concerned with the correct design of this ‘filter’ and aim to render it effective in exploiting the positive influences on it and in nullifying the negative ones, in accordance with the season, regardless of whether these influences stem from the external environment or the interior. Of course, it would be a serious omission not to mention the importance of energy design at the town-planning level, where one has to piece together a puzzle consisting of groups of buildings, of different categories (industrial buildings, homes, offices, recreational buildings, hotel complexes, ect.), the design of open space and the lay-out of the street. It is clear that the earlier and more effectively energy problems are dealt with on this large scale, in the buildings themselves.

As for the energy saving techniques that can be applied in a building, it appears although it is by no means clear that two main categories exist (Figure 16.4). the first category includes the simple methods of conserving energy, involving the application of thermal insulation in the external building elements and interventions in the building’s mechanical systems, while the second category includes strategies for passive solar heating, natural cooling and lighting. It should be noted, of course, that the second category of techniques can only be applied if certain conditions are fulfilled, such as a south orientation for the main façade, the avoidance of shading by adjacent buildings etc., while, as a general rule, the simple methods of energy conversation must also be applied at the same time. The reserve is not true. A combination of both categories, of course, will provide the best possible energy saving solution.

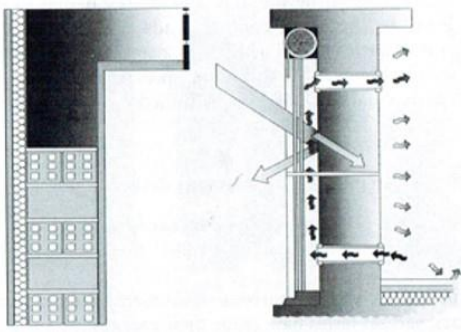


Figure 16.4

A great deal has been written about traditional architecture, which has a lot to teach us about the way in which it has dealt with thermal and visual comfort. It is certain that the anonymous constructors of the past had excellent knowledge of how to solve their problems by working together with nature, since the technological means did not exist to enable them to do otherwise. As is well known, they would position their buildings in relation to the wind, sun, shade, vegetation, lie of the land, etc. thus, with very limited materials and technology, they erected buildings that were well adapted to the climatic conditions of the local area. Nowadays, similar techniques are being employed in modern architecture and these are also the subject of an applied scientific field that is attempting to become part of a wider architectural practice.

A building designed to satisfy certain energy requirements does not have to be 'solar'. there is no need for it to differ from a 'conventional' building, as it is designed and built according to certain energy principles.

3.2.1 Design Guidelines

During the design process, the architect should start with the site layout, the positioning of the building in the plot, the landscaping, the form of the building, which in turn is very closely related to the functional arrangement of internal spaces, the construction of the external elements, the choice of materials, etc. the first and most important stages, especially of the design of buildings in an urban environment, are the study of the site, the spacing between buildings to avoid overshadowing and the arrangement of the exterior by planting, windbreak, the creation of wind channelling etc.

3.2.2 Site Layout

The first basic problem the designer has to face in the urban context is that he/she has to place the building in an already existing built environment (Figure 16.5 b). the case of an empty block is very rare, so it is difficult to propose solutions like the one in (Figure 16.5 a), in order to ensure that the buildings will be facing south, and to avoid overshadowing by adjacent buildings, as indicated by energy-conscious design, so as to permit solar access in

living spaces.
In new settlements there are fewer problems and greater possibilities for implement in energy-saving strategies (Figure 16.6).

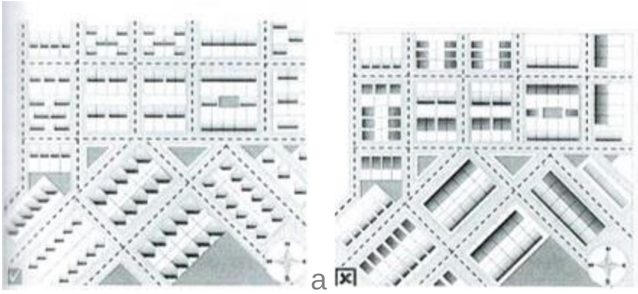
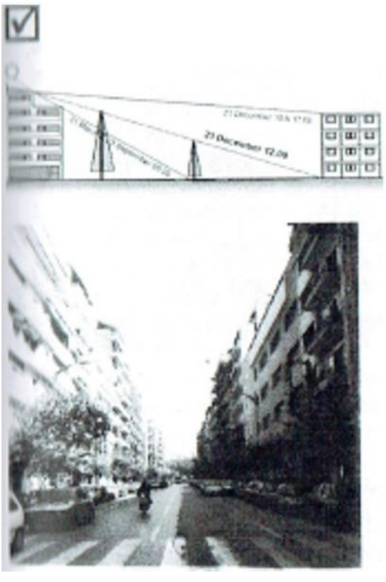

a b Fig. 16.5


Fig. 16.6

3.2.3 The roads

The second basic problem that very often appears in the already formed fabric of cities is related to the road layout. This, as a rule, influences the main orientation of the buildings and the spacing between them. It therefore affects natural daylighting and solar access in the internal spaces, as well as the shading of the buildings and the natural ventilation, depending on the airflow characteristics in the canopy layer (Figure 16.5 and 16.6). Generally, all solutions concerning the positioning of the buildings on a site presuppose a ‘sun lighting-shading’ study, and, as has already been mentioned, an equivalent treatment of all the buildings in the block, taking of course into account the circulation axes and the orientation of the plot (Figure 16.6 b). The parallel arrangement of the roads along the east-west axis is advisable. This solution provides the buildings with the possibility of south orientation (Figure 16.6b). in urban sites the risk of overshadowing from adjacent buildings is fairly high, cancelling the positive impact of south orientation (solar grains, daylighting). If possible take into account the minimum distance between buildings so as to avoid overshadowing and permit the access of winter sun into internal spaces (Figure 16.7).



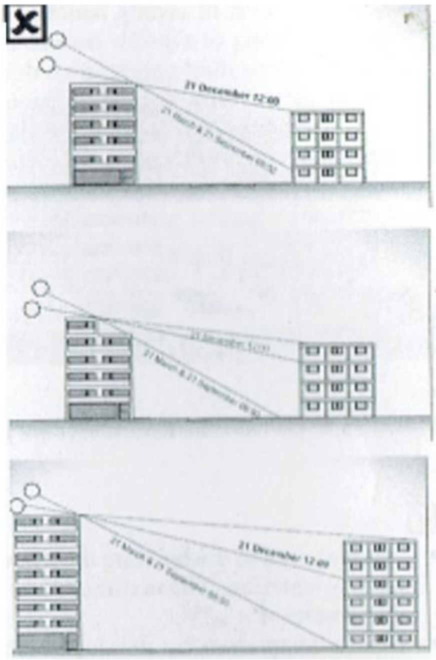


Figure 16.7 a & b

According to Yunnas, the rule is: For any point on a surface, the view of the sun becomes obstructed when the attitude angle of the obstructed object-the obstruction angle q exceeds the solar altitude angle. The parameters that define the obstruction are its height and the distance from the affected surface (Figure 16.8). The distance required between buildings in order to avoid overshadowing increases in proportion to geographical latitude of the location, where the solar altitude decreases correspondingly (figure 16.8a). the required distance also increases when the height of the nearby buildings is increase. For example, in southern latitudes we could locate the buildings closer to each other or we could keep the same distances as in the northern latitudes and increase the height of the building (Figure 16.8). If some storeys in south elevations are overshadowed by other buildings, then these floors should serve for secondary uses (workshops, story\house etc.) that will have a short daily operation schedule and perhaps low temperature demands (no residential). In this case, it is recommended that the two different uses should be thermally separated by insulating the floor between them, in order to eliminate the heat flow from the main us to the secondary one. A different heating plant should also be provided for each use (Figure 16.9) so that the user can stop the heating of the spaces for periods when the space is not in use. For floors with no winter solar access problems, consider passive solar systems for heating, cooling or daylighting. The following site planning considerations, along with the internal organization of individual buildings, can be significant in reducing energy demand.

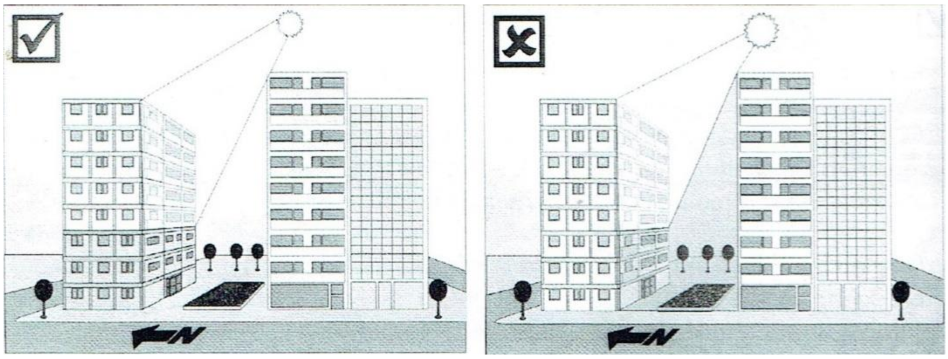


Figure 16.9 a & b

3.2.4 Landscaping to optimize microclimatic conditions.

During the earlier design stage of buildings in the urban environment, it is necessary to include the landscaping of the surrounding area, having as a basic criterion the improvement of the external climatic conditions, both in winter and in summer. The shading and evaporative colling that planting can offer, as well as water surfaces and wind channelling through natural or artificial barriers, reduce the effect of solar radiation in summer, while in winter they shelter the building.

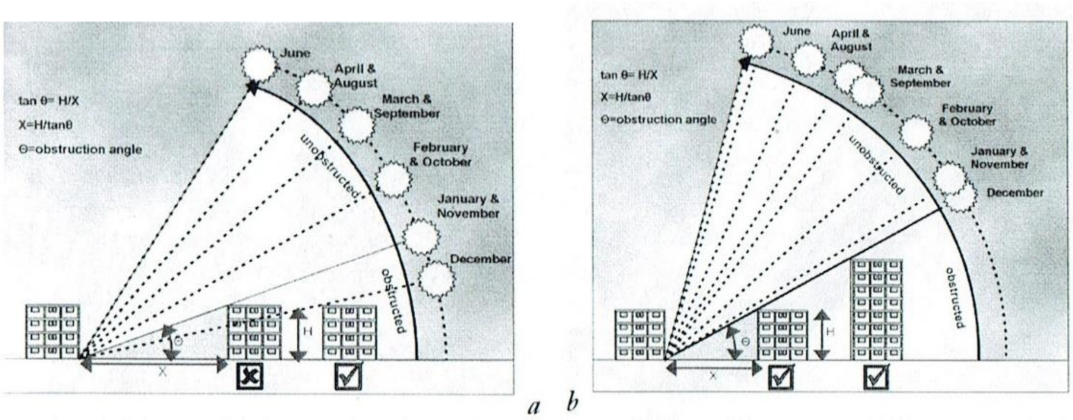


Figure 16.8 a & b

3.3 Vegetation and windbreaks

3.3.1 Vegetation

The lack of planted spaces in urban areas affects more than just the view. Temperatures monitored in areas without vegetation are 5 to 12 K higher in the warm period compared to nearby suburban or rural areas. A study at the University of Athens concluded that the cooling-energy demand of a building in the centre of Athens is almost double that of a building in the nearby countryside. Successful solutions to such problems include the creation of many small sized planted areas, which are more effective than an extended planted area.in the area close to the building the increase in the area planted helps to form better microclimatic conditions and positively affect:

The annual energy balance of the building itself, increasing solar and wind protection, reducing the temperature of the urban environment, and thus improving comfort indoors during summer and mitigating the greenhouse effect; the pollutant concentration; the indoor air quality (IAQ); the sound pollution levels.

In the urban context, the right choice of vegetation, including the type, shape and location of the flora as well as the correct location and size of the plated areas, is therefore important, producing a positive effect during both summer and winter. Some care in the choice and placement of vegetation on or near buildings should, however, be taken to avoid structural damage (Figure 16.13). Evergreen trees placed near the northern façade of a building increase the thermal protection, in accordance with the wind environment and the thermal characteristics of the building envelope.
Deciduous trees on the south side of a building offer natural protection from solar radiation and evaporative cooling in the summer, while at the same time they allow solar access to the internal spaces in winter. Furthermore, trees and grass, or other ground cover plants, positively influence the microclimatic conditions because they absorb large amounts of solar radiation, helping to keep the air and ground beneath them cool, while evapotranspiration leads to further reduction of the external temperatures (Figure 16.14).

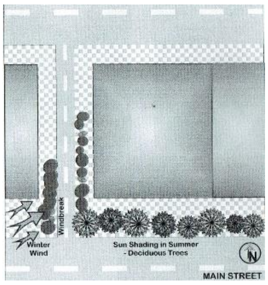


Figure 16.13

Figure 16.14

Windbreaks

The design of the area around a building (the existence or planting of trees, bushes and other plants and barriers in relation to the openings in the building) creates areas of high and low pressure, thus affecting the flow pattern and the speed of the wind (Figure 16.5). it is possible to increase the speed of the airflow towards the inside of the building or over it, or to divide the air current and drive part of it through the building while another part goes above it, by constructing a fence or a hedge around the building. The combination of different windbreaks (low or high walls or trees) and their distance from the building can produce different results (improve cross- ventilation, create a calm sheltered zone behind it.) Gaps in windbreaks, opening between buildings and opening between the ground and a canopy of trees can create wind channels, increasing wind speeds by about 20%. In addition to the vegetation and the different techniques that affect the outdoor temperature and define the route and intensity of the wind, other landscaping techniques include the use of ponds, streams, and cascades for evaporative cooling (Figure 16.6). these techniques should be implemented in warm and dry climates.

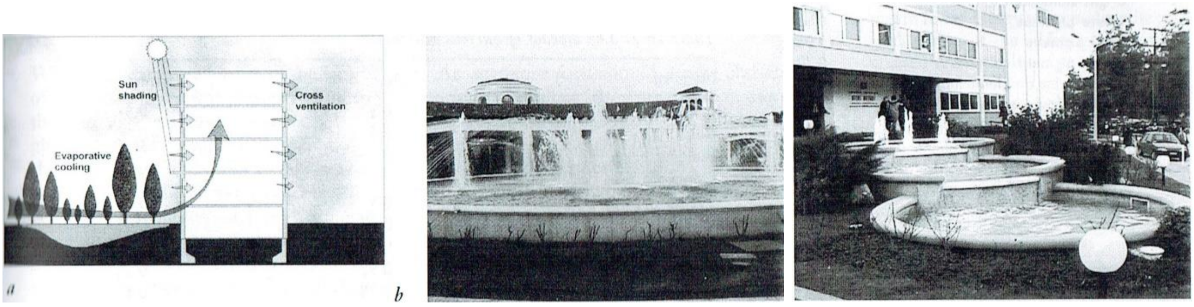


Figure 16.6

The implementation of outdoor evaporative cooling strategies improves the external comfort conditions by decreasing the temperature of the air surrounding the building. As a direct result, internal air temperature, and consequently indoor cooling loads, are lower.

Surface albedo

Surface materials with a high albedo index (reflectivity) to solar radiation reduce the amount of energy absorbed through building envelopes and urban structures and keep their surfaces cooler (Table 16.1). Materials with high emissivities are good emitters of long-wave energy and readily release the energy that has been absorbed as short-wave radiation. Lower surface temperatures contribute to decreasing the temperature of the ambient air, as heat convection intensity from a cooler surface is lower. Such temperature reductions can have significant impacts on cooling-energy consumption in urban areas, a fact of particular importance in cities with hot climates.

3.3.2 The form of the building

The choice of a defensive (closed) or aggressive (open) building.

The decision between these two choices depends on the main orientation of the urban building, the climatic conditions, the use of the building and other design criteria, such as the view, safety, noise, construction cost, etc. Both strategies could lead to the same amount of energy consumption by the implementation of energy saving and/or passive solar techniques for heating, natural cooling and daylighting. The envelope of an aggressive form opens to allow visual and physical contact with the exterior and controlled interaction with natural seasonal changes.

3.3.3 Energy conservation strategies

Thermal insulation of opaque external building elements

In buildings in urban environments where the incoming solar radiation and solar gains are reduced as result of improper orientation or overshadowing by other buildings, the implementation of energy-saving measures probably provides the only solution for decreasing the consumption of conventional fuels. Even in the reduction of thermal loads is possible by increasing the solar gains, the implementation of energy-saving measures by the use of heavy insulation is essential in order to retain I the internal spaces the heat gained. The energy goal set for an urban building (measured in KWh/m² per annum) can be achieved by combining the use of solar energy with energy saving measures, or by implementing heavy insulation in the envelope only. The first option is inevitably the best, although it is not always feasible.

The following general rules are proposed:

The stronger the insulation of the external building elements, the fewer the thermal losses and the smaller the energy consumption of the building in winter (figure 16.40). The first five centimetres of insulations saves much more energy than is achieved by the next five centimetres. A cost -benefit analysis can provide the criteria for the selection of the insulation.

The more complex a building’s architectural form is (having high area to volume ratio), the heavier the envelope insulation must be, in order to balance out the increased thermal losses. The designer should always consider the implications of his decisions. If incorrect decisions are made during the design and construction process, this leads to increased problems for future users, burdening them with the consequences and increasing the cost of energy consumption.

Figure 16.40

Use the same means to deal with the insulation of the envelope, the ventilation, the thermal solar gains and the heating, because they are the basic factors of the building's thermal balance and therefore affect the internal climatic conditions and energy consumption. Insulate the structure uniformly, avoiding thermal bridging. Position the insulating layer so as to provide a thermal capacity appropriate to the heating system, the use of the building and the expected solar gains. The thermal insulation of the building shell will achieve the following: It increases the thermal comfort in interior space. It reduces the possibility of vapour concentration on building surfaces, provided that there are no thermal bridges.

It increases the initial construction cost, but reduces the running costs through the savings energy consumption. It ensures that thermal solar gains will be conserved for a long period in the interior of the building.

Energy saving by insulation the external construction elements

External walls. The external walls structures can be thermally insulated on the outer side, in the cavity of a double wall or on the inner side. The ventilated wall structure method can also be implemented. Figure 16.41 shows the energy saving as a function of insulation thickness.

Particularly in urban multistorey buildings, the thermal insulation of the external walls is the key factor in the final energy consumption.

Flat roof. The roof, the most important structure element of the building shell, always used to be inclined, but has developed gradually and has finally been replaced to a large extent-in particular in urban buildings-by a flat roof. However, problems that are practically non-existent with inclined roofs began to develop as the form of the roof changed. The requirements that a flat roof must satisfy in order to avoid damage and adjust the internal climatic conditions can be summarized as follows: It must be waterproof and damp-proof both from external rain and internal relative humidity. It must have the slopes necessary to facilitate and achieve, in a short period of time, the removal of rainwater. It must provide satisfactory thermal protection in winter and in summer for the spaces it covers.

The above it must be taken into account in the design stage and in the construction of the building in order for the result to be functionally and structurally sound. From the energy point of view the roof plays an important role in low buildings (one the three storeys). Figure 16.42 shows energy savings as function of insulation thickness.

Floor over the ground. By insulating the floor over the ground, energy savings (Figure 16.43) are significantly smaller then those of other building elements. This is because the temperature of the ground is higher than the external temperature. Studies in the urban area of Thessaloniki in Greece have shown that the lack of thermal insulation of floors over the ground facilitates thermal dissipation through the floor and thus the internal conditions during summer can be better in adjacent rooms.

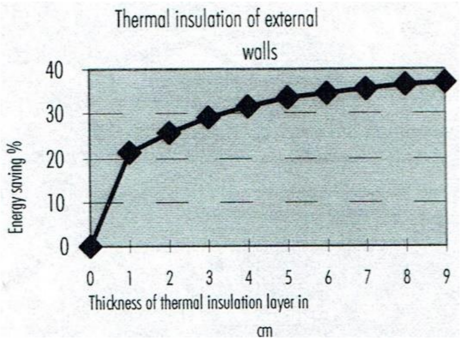


Figure 16.41

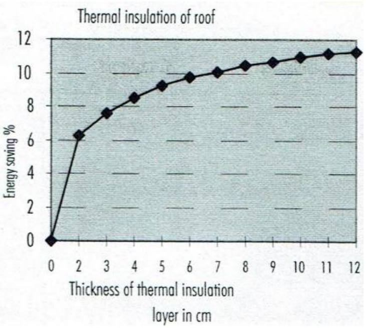


Figure 16.42

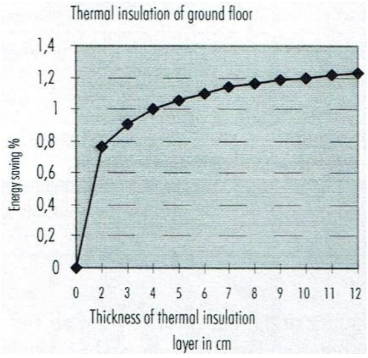


Figure 16.43

3.4 Passive Solar Heating Strategies

The implementation of passive solar heating strategies in an urban buildings presupposes the implementation of energy-saving measures, so as to increase the efficiency of the strategies and to ensure the conservation of heat in the internal spaces for a long period. Moreover, everything in the Design guidelines section (siting and site layout, overshadowing by adjacent buildings, the form of the buildings, etc) should be taken into account.

3.5 Heating Strategy

The heating strategy that uses passive solar systems is based on solar collection, storage and distribution of heat and undoubtedly on heat conservation. Passive solar systems are simple constructions, usually integrated into the building's shell. The materials used are very often common building materials. Their basic goal is to exploit solar energy to the full and to provide a passive form of heating, in order to achieve thermal comfort conditions with the lowest possible energy consumption.in urban buildings, provided that the right orientation is secured and overshadowing from adjacent buildings is avoided, applying the well-known principles of passive solar systems is a simple matter (Figure 16.47).

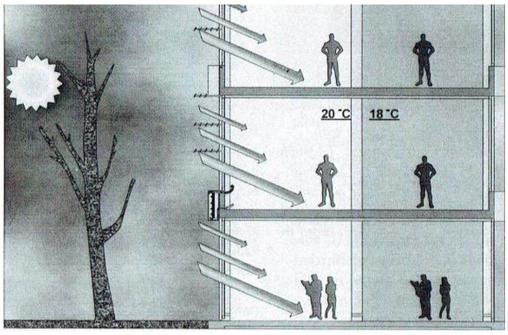


Figure 16.47

The systems that can be applied are as follows:
Direct gain through windows, clerestories or skylights (Figure 16.48); the mass or Trombe wall Figure (16.49 & 16.50)); the thermosyphonic panel (Figure 16.51); the attached sunspace (Figure 16.52); the atrium (Figure 16.53).

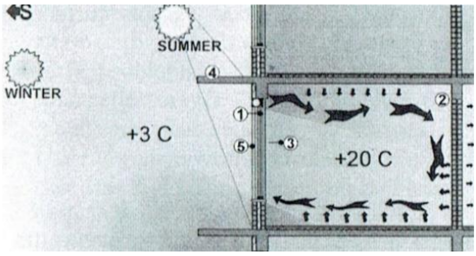


Figure 16.48

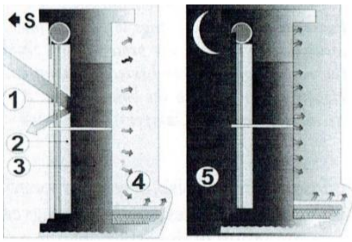


Figure 16.49

To avoid overheating of the interior during the summer, particularly in urban buildings that have high-density use it is necessary to close down any of the systems by providing a suitable form of shading.

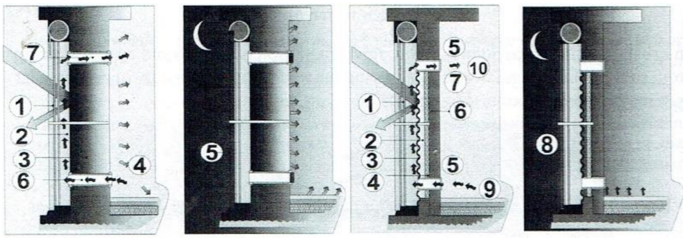


Figure 16.50 & 16.51

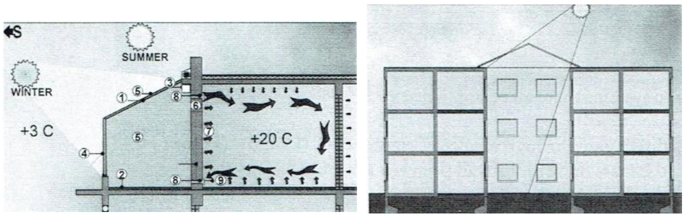


Figure 16.52 & 16.53

3.5.1 Passive Solar cooling Strategies

In urban buildings most of the overheating problems during the summer are caused by heat-producing facilities and installations, by a high level of artificial lighting and by the presence of a large number of occupants or clients, such buildings are office buildings, stores, shopping centres, etc. in residential buildings, the cooling needs significantly lower-with the exception of those in the Mediterranean are. The main reasons are the lack of large heat - producing facilities and easily applied natural cooling strategies such as ventilation and shading.

Control overheating (External Gains Control)

As mentioned earlier several techniques provide cooling through the use of trees, natural vegetation, neighbouring buildings and water near building surfaces, either for shading and evaporative cooling or by wind channelling in summer. A combination of external and internal shading devices can offer efficient solar control.

3.6 Control strategies for Energy Conservation in Buildings

Much has been written about energy conservation in new and existing buildings concerning the energy saving potentials of structural design and system design. Another area of great potential concerns control strategies. Controls are relatively inexpensive and simple to change or adjust compared to other changes which might be made, particularly in existing buildings. In this paper, set point control will be examined for its energy conservation potential. This allows excursions in the inside temperature, taking advantage of the reduced heat transfer and of the stored energy in the building and furniture masses. This must be done with concern for the occupants' comfort, and trade-offs between comfort and additional energy savings must be made.

Since much has already been done in the area of “night setback’’ in both residential and commercial buildings. This study will deal only with occupied hours, on which very little has been done. Tishman Research Corporation has studied several office buildings in New York and has estimated the modest savings shown in Table 1. This study assumed fixed set points during occupied hours. However, Shavit has estimated savings up to 37% in a Pittsburgh office building by allowing set point to ‘’drift’’

Table 1. Energy saving potential for New York office building by set point adjustment.

Strategy	energy	Saving
	Heating	Cooling
Increase set point from 75 F to 80F		4%
Decrease day set point from 70F to 65F and night 62F to 55F	5%	Reducing
lighting to 1 watt/ft2	5%	

3.7 Design of the study

Set Point Control-for baseline energy estimates, a 75F control point was assumed for both heating and cooling. Three levels of discomfort were chosen for comparison. Heating set point 70F and cooling set point 75F. no heating or cooling energy was used when the zone temperature was between 70Fand 57F. this level should be within the comfort zone nearly all the time for people in office activity and dressed in a clothing ensemble of constant thermal insulation value.

Heating set point 68F and cooling set point 78F. this level will probably cause an unacceptable discomfort level and will require some clothing adjustment, winter to summer. In addition, certain weather conditions will require clothing changes during the same day.

Heating set point 65F and cooling set point 80F. this level is felt to be the maximum discomfort which can be reasonably allowed in the United States. It can probably be made acceptable only after considerable education of the occupants on clothing selection and us. In addition , certain weather conditions will cause zone temperature rate of changes during the occupied periode which are outside comfort limits, even if clothing insulation can be changed several times during a single day. Additional insulation problem may derive from adjoining zones at the two extreme set-point temperatures. The result of these three strategies would be expected to show saving opportunities which (1) could be realized with no significant problems, (2) could be realized with some problems, and (3) probably cannot be realized without significant problems, but which may still be practically possible.

3.7.1 Building Selection

Two building types where selected for the study. The first is a single – story office building and the second is a high-rise office building. The single-story building is the one used in the ASHRAE Handbook as an example building for a cooling load calculation problem. Fig. 1 shows its floor plan. Table 2 lists the thermal specifications.

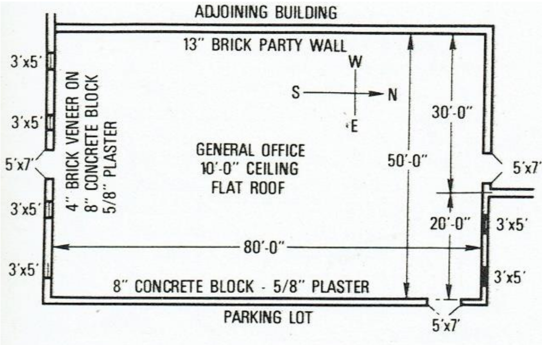


Figure 1. Plan of One-Story Office Building

Table 2. Thermal specifications for the one-Story office building

Section	Net Area, ft²	U-value, Btu/h. ft² F
Roof	4000	0.12
South Wall	405	0.39
East Wall	765	0.48
North exposed wall	170	0.48
Wes and north and east wall	1065	0.25
Doors in north and east walls	70	0.59
Doors in south wall	35	0.59
Windows, single glass	90	1.13

The high-rise building was simulated by employing a single three-Zone module representative of a high-rise building, as shown in Fig. 2 Table 3 list its thermal specifications.

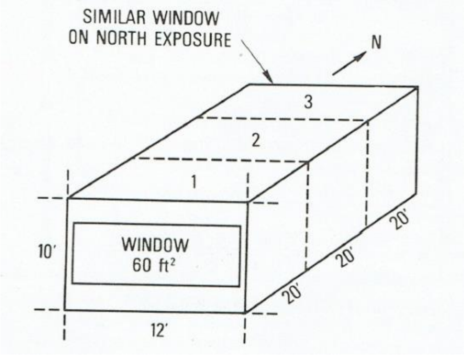


Figure 2

Table 3. Thermal Specifications for the High-Rise Office Module

	Net area ft2	U-value, Btu/h.ft²F
Exterior walls, 4” brick, air	120	0.275
space, 8’’ heavy block	120	1.13
Windows, single glass	1200	0.0*
Floors. 4” concrete	1440	0.0*

Weather Selections-In order to examine weather variation four different locations were chosen. The location, in addition to being representative of United States weather, were also those which have been extensively employed in other studies at NBS, so a good history exists. Table 4 lists the location and degree days.

Table 4. Degree Days for the Four Locations

City	**Degree Days**	
	Heating	Cooling
Minneapolis, Minn.	8316	919
Columbia, Mo	5186	1185
Washington, D.C.	4162	1493
Houston, Tex	1604	2589

Operating assumptions-A comparison of operating assumptions for the two types of buildings is shown in Table.5.

Table 5. Operating Assumptions for Simulated Buildings

	One-Story Bldg	Module of High-rise Bldg
Occupancy-number of persons	85	6
Operating hours-per day	8	10
Lighting during operating hours only-Watts/ft2	5.37	1.7
Air change rate, Operating hours only-per hour	1.91	0.5
Throttling range of control (heating & Cooling) F- each	0	2

3.7.2 Computer program selection for load calculation

The National Bureau of Standards Load Determinations, (NBSLD) was used with the single-story building. This program has been in development for a number of years and has been verified.
For the high-rise building the building the Building Loads Analysis and system Thermodynamics program (BLAST) was chosen. This program was developed at the Construction Engineering Research Laboratory loads (CERL) and has some simplifying as well as additional features compared to NBSLD.

BLAST is essentially a streamline version of NBSLD and includes HVAC system simulation and economic analysis calculations. It also employs a proportional throttling scheme for the modification of heating and cooling capacity in accordance with the room temperature deviation from set point. Both programs are ideally suited for the evaluation of thermostat dead – band control with respect to energy consumption.

3.8 Conclusions

This study has indicated that very significant energy savings in both heating and cooling are possible by using control strategies which allow control points to ‘’ drift’’ without energy use, making use of stored energy in the building components to moderate the rate of change.

To realize the larger savings potentials, more sophisticated controls, providing rate-of-change limits, will probably be necessary. In addition, occupants will need education in clothing insulation control. Moderate savings, obtained by allowing a 5F ‘’drift’’ zone, could be realized without rate-of-change controllers or clothing education, within the limits of reasonable occupancy rates.

Much more research is necessary in the areas of human response, controls, and overall system performance in order to realize the maximum savings, and to further assess the tradeoffs between energy-savings and human comfort and performance.

Chapter 4

This chapter discusses the use of resources such as materials and water in the construction of buildings as well as its implications to the environments. All products used in building construction require transforming raw materials extracted from the environment. They are various informed strategies for using material inputs efficiently, such as using recycled and reclaimed wastes as inputs, will be discussed lake of water is another major constraint to industrial and economic growth. The concepts of embodied energy and embodied water are introduced in this chapter. The ways to improve water efficiency in buildings will be also discussed.

The environmental impacts of building materials result from related energy use and emissions, the depletion of finite material sources, and the undesirable accumulation of materials in landfills. The activities causing these impacts include the mining and harvesting of raw materials, the processing and manufacturing of finished materials, transporting materials, the use of hazardous materials, and the generation of construction waste. Through judicious building design and material selection, we can substantially reduce these impacts.

In the process design, we can anticipate and are able to support future, reduced impacts of the material waste generated by building operations, as for example through the design of recycling areas in the building, planning for the disposal of hazardous materials, and planning for the eventual deconstruction and reuse of building materials.

The use of energy to harvest and process materials is referred to as embodied energy. It is an important and increasingly quantifiable property that comprises part of the accounting of the environmental impact of buildings. And, as buildings are designed and built to use less energy, the fraction of energy use represented by embodied energy increases.

Finally, the impact of construction debris can be minimized through planning during the design phase and thoughtfully applied procedures during construction.

Lack of water is another major constraint to industrial and economic growth. The concepts of embodied energy and embodied water are introduced in this chapter. The ways to improve water efficiency in buildings will also be discussed.

4.1 Sustainable Resources management

the resources used in the construction section which can be viewed under six major themes as follow:

Sustainable sites- select the site to maximize the use of existing infrastructure by selecting the sites close to already -developed areas and public transport, protect or restore habitat, minimize impact of construction on storm water, reduce heat island effects, etc.

Materials and resources- Reuse of buildings after renovation, recycle of materials, use of local materials, use of rapidly renewable materials, etc.

Water efficiency-minimize water usage for landscaping, reduce water usage in building with efficient fixtures and rainwater harvesting and use innovative wastewater technologies.

Waste management- reduce the amounts of waste generated during all stages of construction process. Reuse, recycle and recover as much waste as possible. Adopt waste heat recovery, practice-controlled dumping, etc.

Energy and atmosphere- proper commissioning of building's energy system, minimization of energy usage, on site renewable energy and proper usage of refrigerants. Indoor environmental quality-minimize sick building syndrome, improve indoor air quality, minimize the impact of construction activities on indoor air, improved daylighting, etc. In this chapter as well will discuss the sustainable resource management of materials and water.

4.2 Global Material Consumption Trend

It has been reported that globally, the total amount of materials extracted, harvested and consumed is about 62 billion metric tonnes (Gt) in 2008, showing an increase of 60% since 1980 (Lutter al., 2014). The primary sectors for increase global demand are construction minerals, biomass for food and feed and fossil energy carriers. These three groups account for 80% of total global material extraction. Among the different resource extraction, biomass extraction is about 33%, followed by construction minerals, fossil energy carriers and metal ores beings 30%, 20% and 13%, respectively. It is also truth that the resource extraction from non-renewable sources has increase during the last century, while showing the decline in the extraction from renewable sources. Fig 5.1 Shows the material extraction rates from 1980 to 2008, representing the contribution of each sector.

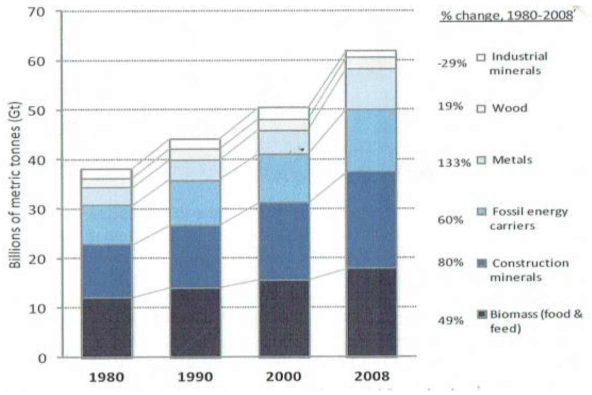


Fig. 5. Global material extraction trend

The construction sector represents the major contribution to the material consumption in many countries around the world, including Australia. In Australia, the percentage of consumption in construction sector and other sectors is summarised, as seen in Table 5.1. It is understood that approximately, 90% of the production of construction materials was consumed by construction.

Consumption of materials by end use in construction (Newton, 2001)

Materials	% of total consumption
Iron and steel	12
Construction materials (concrete, brick, gravel, sand)	90
Timber products	55

Plastic products	27

In selecting timber for use, it is important to distinguish plantation timber (which is a renewable material) and timber from old growth forest (which is much less renewable).

4.3 Sustainable Material Management

Any product is embodied with energy, which is consumed during processes in association with the acquisition of natural resources, production, and supply to final consumption. The processes may be involved with mining, manufacturing, transport, and other sectors. Therefore, proper selection of materials for construction may not only lead to the significant improvement of indoor comfort, but also reduce environmental impacts, which is also affected by the effectiveness in reuse/recycle and transportation of materials and their products.

To reduce the environmental impact due to material consumption, two approaches may be considered through the life cycle of building construction and service. One approach is to directly reduce new material consumption, and another is to reduce embodied energy (and embodied water).

Reduce material consumption by:

Reducing the consumption of materials directly during the planning and design stage.
Using recycled materials and products with recycled materials. Recycling buildings materials can reduce embodied energy substantially. For example, aluminium is 100% recyclable. Recycling aluminium reduces embodied energy by 95%, while recycling steel reduces embodied energy by 72% (Milford 2011)
Reuse materials and products.
Using durable materials and products, with their service life equivalent to projected building service life.
Consuming rapidly renewable materials.
Using innovative and emerging construction methods to reduce material consumption.

Figure 5.2 shows an aspect of reducing the material consumption at design stage by eliminating the exterior and interior plastering in brick veneer buildings. Although the brick surfaces are exposed visibly, they do not reduce the aesthetic appearance of the building.

Construction methods also significantly contribute to the amount of materials consumed. For instant, on-site construction without proper planning would make up enormous amounts of offcuts and waste, and cutting down such offcuts with proper planning would reduce the amount of material consumption. Bricks when cut to half or any other size will result in the remaining half unused. Similarly, reinforcement is heavily wasted during the construction as the offcuts are generally not used. In order to minimise the material consumption, we would like to discuss two innovative or emerging construction methods that could significantly reduce material consumption and, hence, waste:

Off-site or modular construction: Modular construction is an innovative construction process whereby a building is constructed off-site (possibly in a factory), under controlled and well-planned conditions, using the same materials and meeting the standards to conventionally constructed buildings. As this construction method produces similar modular units again and again, the material consumption is well planned ahead without significant offcuts. Most importantly, they use permanent form works for construction that could substantially eliminate the material consumptions for form work in on-site construction. Figure 5.3 shows the construction of a modular unit and assembly on-site.

Fig. 5.3

Figure 5.3

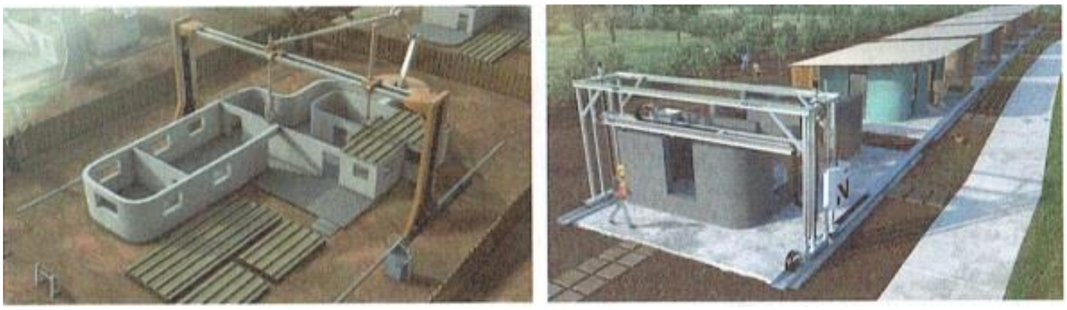


Fig.5.4

Freeform or digital construction method: the freeform construction methods construct building on-site without the use of formwork for construction. The geometry of the building is digitally embedded into the robotics, which moves in the designated path for constructing the building as layer-by-layer. It is similar to three-dimensional (3D) printing of plastic objects: however, it uses concrete as a key construction material with or without reinforcement. As this method freely construct the building without the formwork, the material consumption for formworks could be significantly reduced, in addition to reducing the construction material waste. This method is in its infant stage and requires a significant research and innovation to implement in construction (Fig. 5.4).

Reduce embodied energy by:

Using materials that require less energy to extract and process. Using materials and products, which may need less transportation for building construction and service. Recycling building materials can reduce embodied energy substantially. For example, aluminium is 100% recyclable. Recycling aluminium reduces embodied energy by 95%, while recycling steel reduces embodied energy by 72%.

Figure 5.5 is an example of using locally sourced soil for making a cascade system with cement-stabilised rammed earth (CSRE) walls. CSRE uses soil as a main ingredient with very little amount cement for stabilisation. The use of excavated soil for constructing the wall will not only reduce the landfill soil waste, but also reduces the material consumption for construction. Meanwhile, the process to extract materials by mining or harvesting for building and construction can cause adverse impacts on landscape and biodiversity, leading to land depletion or degradation and loss of natural species. The process with less environmental impacts should also be considered in the selection of materials. However, in addition to cost, material section should be balanced with the building performance requirements, for example, thermal performance, which may effectively make a significant difference in operating energy consumption of buildings.

4.4 Using Less Material

The greenest material selection is that which minimizes the amount of material used. Large potential savings in materials can occur during the site selection phase not to the design of the building itself but rather to its sitting and infrastructure. By locating buildings in already developed areas, one is able to use existing infrastructure materials. Infrastructure such as roads and municipal water systems are essentially reused as they are shared and the potential material consumption of materials for new infrastructure is averted. Two powerful approaches to green building design were discussed earlier in the context of energy efficiency and also offer savings for material use reduced floor area will use fewer materials and less embodied energy than a larger building. A building with fewer tall ceiling will use fewer materials and less embodied energy than a building with taller ceilings. A simpler geometrical structure will use fewer materials and less embodied energy than a more complex structure. A single larger building will use fewer materials and less embodied energy than multiple separate buildings serving the same function.

Another approach to reducing material use is through material efficient design. Earlier, we discussed advanced framing techniques, especially in the context of reducing thermal bridging. In so doing, less material is typically used. Examples include using 24-inch (610) stud spacing instead of 16-inch (405) spacing; single headers and single top plates; single studs at window and door openings; and simplified corners such as the two-stud corner. The prior discussion focused on exterior walls and on energy losses due to thermal bridging. For material use reduction, interior walls can also be examined. Instead of standard 16-inch (405) spacing for both wood studs and steel studs, 24-inch (610) is allowed by code and can be considered. Another example of material efficient advanced design is the use of frost-protected shallow foundations instead of regular foundation walls with footings. Frost-protected shallow foundations have been successfully used in the United States and over 1 million homes have been built with these foundations in Scandinavian countries.

Eliminating attics in pitched-roof buildings is another approach to reducing material use, as two structures -the attic floor and the roof are combined into one. When detailed structural design is done, rather than using rules of thumb or age-old practices, opportunities for reducing materials may be identified. For example, a 4-inch (100) thick concrete slab might well be feasible for a particular floor, rather than a 5-inch or 6-inch (125 or 150) thick slab. Another approach to reducing material use is by avoiding finishes where they are not needed. Sometimes referred to as "structure as finish," this approach allows structural elements to serve the dual purpose of structure and finish. Trade-offs with the need for added lighting should be carefully evaluated if the exposed structure has a low lighting reflectance. Yet another approach to reducing material use is to leave components such as ductwork or piping exposed. This reduces material use for gypsum board and associated furring for chases soffits, and plenums, as well as finishes.

A final approach to using less material is to generate less waste-in other worlds, to avoid generating waste. This does not refer to directing waste away from landfills or to reusing waste, which are addressed separately, but rather to generating less waste to begin with. This means planning the design such that lengths of structural members factor into lengths of commercially available structural stock, whether of wood or steel, and similarly with areas of such components as sheeting and gypsum board. It can mean developing cut lists for lumber and sheet stock, which allows placing orders for the correct quantities of needed materials rather than ordering and discarding extra material. It can mean mixing fresh concrete in the correct required quantities rather than in excessive quantities. Prefabricated assemblies, such as structural insulated panels (SIPS), possibly lend themselves to less waste through computer-designed lists of materials.

Design professionals can play a key role in materials-efficient design by providing additional information in the construction documents relating to material quantities. For example, noting volumetric quantities of materials on drawings, such as concrete, asphalt paving, and blow insulation, can help contractors prevent waste due to over-ordering. Similarly, providing area quantities on drawings for roofing, sheeting, hardscape, and landscaped areas can facilitate ordering correct quantities. Full detailing of framing further supports accurate take-offs and further reduces the potential for over-ordering and waste.

Using fewer materials through design applies not only to architectural components but also to mechanical and electrical components, such as lighting, heating, and cooling equipment. As addressed earlier, efficient lighting design typically means fewer light fixture, as design is optimized for the required level of lighting rather than over-lighting by rules of thumb. Other green lighting design techniques also reduce material use. For example, a building with fewer tall ceiling and more reflective surfaces requires less artificial lighting, which means not only less operational energy use but fewer light fixtures as well, resulting in less material use and less embodied energy. Similar benefits accrue to well- designed buildings and their heating and cooling system. The heating and cooling systems can be smaller not only through efficient building design but also through accurate sizing of the systems. Heating and cooling equipment, such as heat pumps, can be smaller and the distribution network, such as piping, radiators, and ductwork, can be smaller. Optimally sized heating and cooling equipment and distribution systems require less material and less embodied energy.

Materials conservation is also possible through the use of the imperfect materials. Select woods, for example, implicitly means that some wood has not been selected and has been discarded. Much rejected wood is structurally sound. Imperfect stone and brick pieces can be usefully applied on a green construction project if they are planned for. Likewise, many other salvaged materials can be accepted rather than rejected if quality control focuses on integrity of function rather than perfection of form. In a new green aesthetic, imperfection can be exalted as a feature rather than scorned.

Material conservation is facilitated through well-planned design and construction. In this regard, accelerated schedules work against green design, as design professionals tend to fall back on rules of thumb and might not design component-by-component or room-by-room. Green building projects do not need to be synonymous with slow schedules, but adequate time should be allowed for the detailed design of each major building component to minimize material use. Adherence to best practices can substantially reduce material quantities.

For example, when fastening rigid insulation to an exterior wall, it has been traditional practice to use 25 to 30 fasteners per 4x8 foot (1,220x2,440) sheet of insulation. However, it has been shown that 10 to 12 fasteners are more than adequate to fasten such sheets without bowing, bending, or risk of separation. Similarly, taping exterior rigid insulation has been shown to be done rapidly and effectively using a tape applicator rather than being

hand-applied by removing tape-baking paper, significantly reducing taping waste.

4.4.1 Reused Materials

To minimize the embodied energy required to harvest and process new materials and to minimize depletion of raw material sources, we seek to reuse materials where possible.

4.4.2 Salvaged materials

Materials salvaged for reuse include much of what is required for construction-dimensional lumber, doors, windows, wall coverings, kitchens specialities, gypsum board, plywood, insulation, siding, moldings, hardware, block, brick, pavers, flashing, roofing shingles, and unused containers of products such as adhesives, caulk, and grout.

As series of questions arise about the merits of reusing energy consuming components, such as lighting fixtures, heating and cooling equipment, and motors, as well as water-consuming equipment, such as toilets and faucets. The key environmental issue is whether the embodied energy of such equipment is greater or less than the potential savings from installing new high-efficiency equipment over the expected life of the equipment.

There are parallel questions about the financial viability of such reuse, which may or may not give the same answer (yes or no) as the embodied energy question. They may also be legal issues, such as selling low-efficiency equipment that does not comply with federal minimum efficiency requirements. Separately, installing low-efficiency equipment may run counter to some building codes.

4.4.3 Reuse in place

Another approach to reusing materials is to reuse existing buildings altogether, which further reduces embodied energy use by eliminating the transportation of materials.

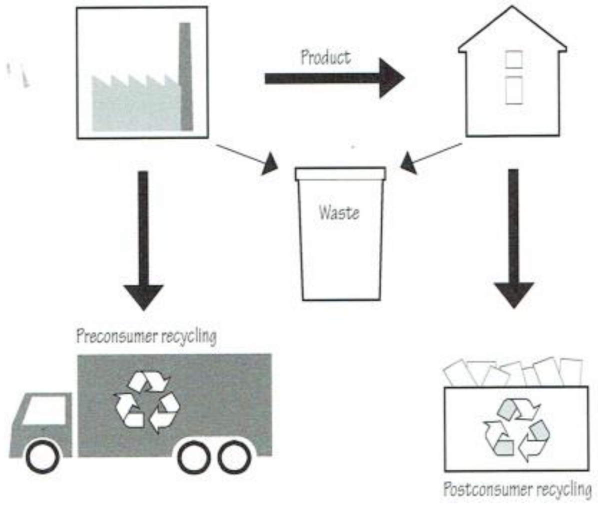
We call this adaptive reuse. Structural elements such as floor, walls, and roofs can typically be reused. Non-structural elements, such as interior walls, floors, and ceiling finishes, can often be reused as well.

An interesting question arises about the energy impacts of whether to reuse existing buildings or to rebuild. If we assume that the embodied material in a building represents one-quarter of the energy that will be consumed over the life of the building, then a new building need only be 25% more energy-efficient than an existing building to warrant replacing the existing building and still have a lower life-cycle energy use. Many old buildings are intrinsically inefficient, not only in their insulation and airtightness but in a variety of characteristics. To be prudent, the comparative life-cycle energy consumption might be assessed as part of the decision to reuse an existing structure.

4.4.4 Materials with Recycled content

Used of materials with recycled content is encouraged. Preconsumer recycled materials are those that are diverted from the waste stream during manufacturing. Postconsumer recycled materials are obtained from the waste generated by end users. Concrete is the most-used construction materials. Concrete can contain recycled aggregate, which is crushed concrete after the removal of reinforcement and other embedded materials. Concrete can also be specified to contain fly ash, which is a by-product of coal combustion, or slab, which is a by-product of smelting metal ore. Steel fabrication uses a high quantity of recycled steel in its feedstock, reportedly rising above 90%in recent years. Wood derivative products, such as a variety of engineered wood products, also can contain recycled material.

Gypsum boards is available with recycled content, including recycled agricultural materials, fly ash, slag, and other fillers. Even when materials have some of substantial recycled content, trade-offs with the chemical content and embodied energy are worth examining. For example, particle board is largely made of recycled materials but its chemical content, including formaldehyde, a known carcinogen, has been significant. And although steel is over 90% recycled, it still has substantial embodied energy.



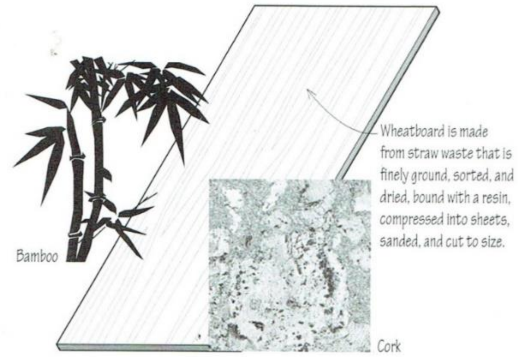
4.4.5 Selection of Previously Unused Materials

With material use minimized and reused and recycled materials maximized, we turn our attention to selecting previously unused materials. Desirable optios include rapidly renewable materials, natural materials, nonhazardous materials of low toxicity, and locally procured materials having low embodied energy.

4.4.6 Rapidly Renewable Materials

Rapidly renewable means materials that grow naturally and can be harvested in a short number of years, such as the ten-year period defined by LEED. Examples include bamboo flooring, cork flooring, carpet fibre derived from corn, cotton insulation, natural linoleum, natural rubber flooring, soy insulation, straw bales for walls and insulation, strawboard cabinetry, wool carpeting, and wheatboard millwork and cabinetry.

By using rapidly renewable materials, we reduce the depletion of materials that take longer to grow, such as wood from old-growth forests, or that derive from finite resources, such as plastics derived from fossil fuels. Choosing the right application is important for rapidly renewable materials. Bamboo floors, for example, may not be so durable in high traffic areas or in spaces with excessive moisture.



4.4.7 Other Natural Materials

Wood is an age-old and widely used natural material in construction. Wood is used for structural and non-structural framing, flooring, subflooring, doors, windows, built-in furniture, wall and ceiling finishes, fencing, and much more. Wood is also used for temporary structures during construction, such as scaffolding and guardrails.

While wood is a natural material, it can be harvested and processed in environmentally destructive ways. These include the logging of old-growth forests, loss of forest cover, logging of threatened tree species, and use of hazardous chemicals. To assure that wood used in construction has been harvested and processed in environmentally sensitive ways, a common requirement is for construction lumber to be certified by the forest stewardship council (FSC). Cross laminated timber (CLT) is a recent development in which layers of dimension lumber are oriented at right angles to one another and bonded under pressure with adhesive to form structural panels. CLT offers good strength, low weight, and low embodied energy. It has been successful use even in mid-rise and high-rise buildings.

4.5 Designing for Reduced Postconstruction Material Impacts

During the design of new buildings, provision can be made for reducing postconstruction material impacts; for example, through reducing material use after the building is built.

For example, rooms or space can be provided for an integrated system of solid waste management, including areas for collection and storage of recyclables, areas for collection and redistribution of products and equipment to be reused, and areas for composting, such provisions make it easier for occupants to divert waste from landfills by recycling, reusing, and composting. Further, materials, used in construction can be documented so that replacement can be minimized. For example, if product details for paints, such as manufacture, paint colour and number, and local sources for purchasing, are well-documented in an owner's manual or in product submittals, it is less likely than an entire room will need to be repainted if touch-up painting is required: only small quantities may need to be ordered. This applies to consumables such as paints and wood finished, as well as to window and door trim, molding, blind, shingles, and minor furnishings. Designing for deconstruction facilities the eventual reuse of building materials when the proposed building reaches the end of its own life. Principles of designing for deconstruction include using modular construction; simplifying connections; selecting fasteners that allow for easier deconstruction; reducing the number of fasteners where possible; selecting durable and reusable materials; and reduced building complexity. The building-specific documentation of design for deconstruction can facilitate such deconstruction in the future.

4.5.1 Construction Waste Management

A major focus of construction waste management is to reduce waste to avoid filling landfills.

4.5.2 Less Waste through Material Use Efficiency

The process of construction waste management was previously begun through attention to material efficiency during design and procurement. But identifying material quantities in more detail, efficient procurement is facilitated, which results in less waste.

4.5.3 Protecting Construction Material before Use

Priority here is also given to protecting construction materials onsite before use. Our goal here is not only to prevent damage to materials that would diminish their function but also to prevent moisture damage that could lead to indoor air quality problems due to colonization by fungi, and to prevent material waste due to rejected materials. In the later context, over time we will likely see additional attention to material shipping to prevent damage during shipping that might lead to the rejection of materials.

Quality control practices will perhaps also become more forgiving to allow acceptance of materials with very minor or superficial damage, leading to reduced material waste without compromising a building's integrity.

4.6 Zero Waste

In response to environmental damage from waste of all kinds, a movement has arisen to design zero waste buildings, the Zero Waste International alliance defines zero waste as the "construction ao all resources by means of responsible production, consumption, reuse and recovery of products, packaging, and materials without burning and with no discharges to land, water, or air that threaten the environment or human health."

We might wonder how this might even be possible: how can a building be built with zero waste? How can a building reach the end of its life and not create waste? For many, the ostensible improbability of zero waste can serve as an obstacle for considering it. Some people use zero waste as a long-term goal rather than as an immediate absolute goal.

Others find helpful to think of "net-zero" waste buildings: if a new building can incorporate materials from and old building at the same site, or if it reuses materials that have been discarded from another building, the new building has prevented materials from being discarded, and so we can regard it as having "gained credit" in material use. This credit can offset materials that cannot be prevented from being discarded. If the reused materials do not exceed the discarded materials, the building is "net-zero" with respect to waste and could even be net-positive. For others, nothing short of eliminating discarded construction waste, or even discarding any materials from the one-day-to-be-demolished building, fits the definition of zero waste. We might call this absolute zero waste. The goals of zero waste buildings call for using our full and broad set of strategies for material conservation:

Reducing use in design through material minimization. Accepting imperfect materials if functionally acceptable. Specifying salvaged materials, employing adaptive reuse where possible Requiring maximum waste stream diversion for reuse, specifying demountable fasteners and other deconstruction approaches rather than adhesives.

Planning is key and needs to be fully incorporated into the life cycle of building. From design to end-of-life. For example, the Living Building Challenge requires a Materials Conservation Management Plan for each the following phases: Design, Construction, Operation, and End of Life. Waste reduction cannot happen without planning, just as planning cannot happen without setting a goal. Getting to zero waste is all about setting the goal, planning to meet the goal, and then implementing the plan. Rather than treating the goal as unachievable, reducing and even eliminating waste introduces an existing set of challenges with an environmentally positive outcome. For early adopters, it is an opportunity to learn and teach. Over time, with all d\green design practices to become standard practices. With a goal of zero waste, we promote the view that waste is something of potential value and reuse, and that preventing it from being discarded has separate further value in reducing pollution, rather than limiting ourselves to the view that waste is a nuisance to be discarded.

4.7 Sustainable Water Management

Water is an essential part of every life. Human consumes water for domestic use, agricultural use and industrial demands. Globally, the total volume of water on the earth is about 1400 million Km3 of which only 2.5%, or about 35 million Km3 , is freshwater. About two-thirds of the fresh water remains as ice caps and glaciers, which human cannot use. The remaining one-third of the freshwater is accessible by human as either groundwater or surface water. Fig.5.6 shows the distribution of the earth's water.

On average, about 312 billion gallons of surface water and 77 billion gallons of groundwater are consumed by human daily. Like any other resources, the water consumption is also continuously increasing, and the major factors causing increasing water demand are increasing population growth, industrial development and the expansion of irrigated agriculture. Agriculture accounts for more than 70% of fresh water drawn from lakes, rivers, and underground sources. In Australia, 70% of total water withdrawal is used for agriculture (calzadilla. 2010). Rainfall is the major source of water in Australia, becoming.

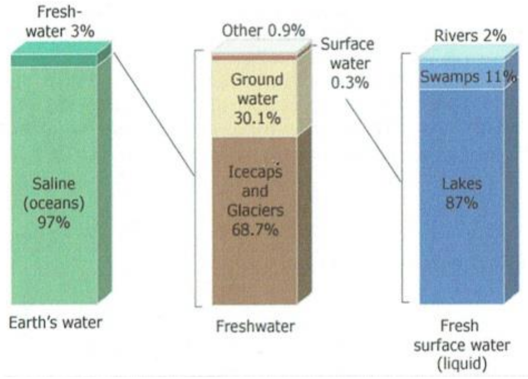


Fig.5.6

Run-off that goes into rivers, lakes, dams and aquifers
Ground water recharge by infiltration that varies the water table.
Water storage on the land surface or underground to supply agriculture, industry and urban users, including large dams, farm dams and aquifers.
The quantity of water stored above ground, such as dams, and below ground, such as aquifers, is determined by the volumes of run-off and recharge from rainfall. However, in Australia, there has been an extreme variability in rainfall both across the continent and from year-to-year. As a matter of fact, there are considerable areas in Australia that have been experiencing prolonged draught, as rainfall fell short of the average quite significantly in the past years, as shown in Fig. 5.7. water saving now becomes one of the most important issues in Australia.

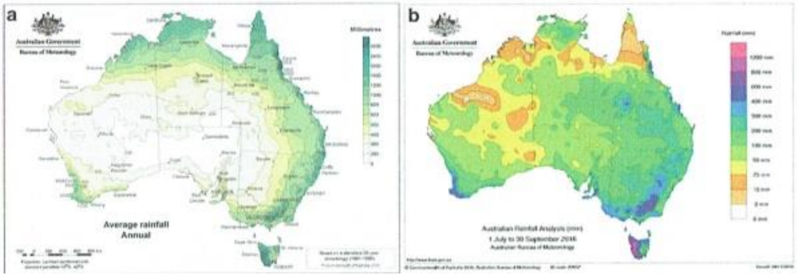


Figure 5.7

4.8 water Efficiency and Recycling

Water movement between biosphere, hydrosphere, atmosphere, and lithosphere is known as a biogeochemical cycle. Figure 5.8a shows the movement of water between different elements in the earth. Nevertheless, the water movement in the urban environment is the crucial part that requires assessment, because urban environment may disturb the natural water cycle due to the urban building density, less vegetation and impervious surfaces. Water cycle in urban environment can be described by Fig. 5.8b, starting from dams and water tanks for some households, sourced from rainfall. The water would then be treated and delivered to household.

Household water may also be sourced from recycled water. It has been found that in Australia, households use about 59% of urban water; of that, 54% of the water used in the average Australian household is used for flushing toilets and watering gardens. The water use efficiency should be improved to prevent continuously increasing water extraction to meet the demands of increasing population and the human life-style. The following are few ways to increase water efficiency:

Changing human activities (shifting to more water-efficient crops, changing industrial processes away from water-intensive production).

Adopting existing technology (such as drip irrigation, low-flow toilets and better industrial processes). Adopting water efficient irrigation technology.

Changing the water consumption practices such as preventing irrigating during the day, preventing the use of potable water for landscapes irrigation. Identifying and preventing wasteful leaks.

Changing proper prices for water. On the other hand, when assessing efficiency of water usage in buildings, the following factors should be considered:

Water-saving devices: low-flow fixtures (toilet, urinals, faucets and shower-heads), no-flow fixtures (composting toilets and waterless urinals) and controls (infrared sensors).

Use of rainwater: collection, storage and, if necessary, treatment of rain falling on structures in the built environment.

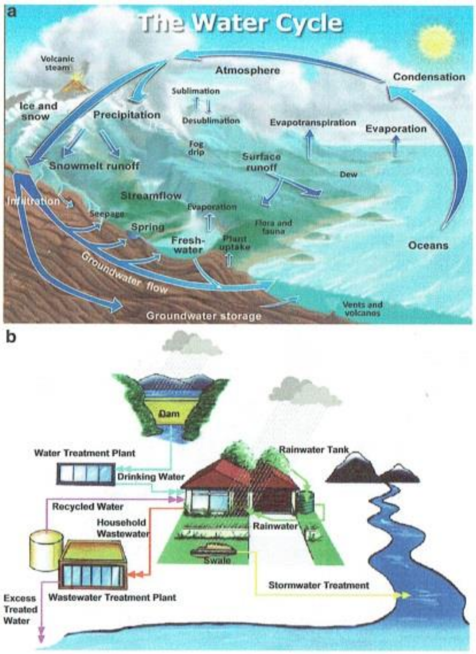


Figure 5.8

Use of storm water: collection, storage and treatment of rain falling on hard surfaces and running off the built environment. Reuse or recycling of grey water: reuse domestic sewage effluents or municipal wastewater, preferably from which industrial effluents containing processing chemicals have been segregated. The recycled water may be reclaimed from bathroom and laundry effluents (grey water) or from the entire domestic sewage stream (black water) or municipal wastewater.

4.8.1 Water Quality and Treatment

Another important issue with water resources is the contamination of the water supplies. Fig 5.11 shows the contaminants in water on short and long terms. The discharge of hazardous waste products particularly in manufacturing processes could be a major cause of contamination in the long run. The quality degradation of natural water has serious consequences on human health, it must be stressed that, apart from natural contaminations, the anthropogenic pollution has major concerns that are irreversible.

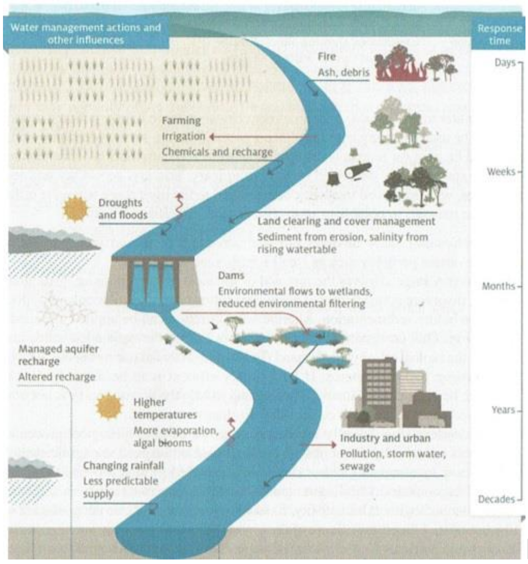


Fig. 5.11

4.8.2 Rainwater Tanks

Rainwater tanks offer a smaller environmental footprint than dams or desalination plants at a domestic or an industrial level. The main advantage of having a rainwater tank is that the owners could avoid the consequences of city-wide water restriction; they many partially offset their annual water bill, and, in some areas, rainwater may offer a better aesthetic than the city drinking water supply. The yield of a rainwater tank is directly related to the rainfall and the tank size. Although day to day fluctuations in rain fall is significant, the yield of a tank over a period is less volatile than large waster storge options such as dams. The rainwater tank yield primarily depends on: Rainwater collection area (roof size), tank size, the number of occupants in the house, garden requirements, whether the tank is plumbed into the house, and if so, to which areas. Considering the above factors, a simple formula to determine the rainwater tank yield is shown in the following equation: Yield=Ax(Rainfall-B)xRoof Area

4.8.3 Desalination, Recycling, and energy

Desalination and recycling of water plants have been seen as an effective means to cope with water shortage in Australia. Desalination in Australia is a relatively expensive way to produce drinking water.

However, over the past decade, improved technologies have reduced the cost of desalination. It should be reminded that both desalination and recycling process consume energy. It should also be carefully considered that energy use for water treatment has been associated with environmental costs, such as greenhouse gas emissions. The process also produces a brine waste product that has potentially hazardous effects on the marine environment.

The resource efficiency is a major concern in built environment as the current practices use more non-renewable resources that the renewable.

This chapter discussed sustainable resource management with the discussion on resource efficiency in materials and water.

The global material consumption trend showed the necessity of implementation principles of efficient material consumption for the construction sector. Various methods of sustainable material management methods and strategies are discussed.

The water efficiency in built environment is also discussed with the methods to the efficient water consumption in buildings and the consequences of unsustainable water consumption practices.

Chapter 5

Sustainable buildings can be explained in two parts to their importance, Sustainable building design and Sustainability and building as two aspects of the same topic.

5. Sustainable building design

After having a clear-cut knowledge on resource efficiency, carbon emission and environmental impacts in building and construction process, this chapter will discuss the information that is of direct practical use for sustainable construction. It lists the key indicators that need to be considered for management to be sustainable. In practical terms, sustainable construction is an implementation process that minimises the negative impacts on natural surroundings, with minimised consumption of natural resources and without compromising the essential needs of people trough the full life cycle of buildings and infrastructures.

The implementation of sustainable construction management has to meet the objectives of key organisational, social, environmental and economic performance indicators.

For example, the purpose of building construction is to improve the indoor environment to make it more suitable for human occupation. These include thermal comfort, lighting, acoustical comfort and indoor air quality. Indoor environment is therefor one of the main considerations on the aspects of building performance in relation to sustainable construction. This chapter also discusses the features of good indoor environment, assessing methods of indoor conditions and design aspects to achieve good indoor environment.

5.1 Sustainable building design Opportunities

The design approaches used for sustainable building construction imply various concepts including green buildings, low energy buildings, high-performance buildings, zero-carbon development, etc. although different concepts or definitions are introduced, they all aimed to have less negative impacts on the environment than standard buildings.

The design principles often consider low resource and energy consumption during the construction and operation stages and general low waste during demolition. However, the principles applied to each definition may vary with their scope. In this chapter, we will discuss Two major sustainable design concepts of:

Green building design
low energy building

5.2 Green Building Design

Green building take the sustainable design approach, which aims to have less negative impact on the environment than standard buildings. The design often considers construction with minimized on-site grading and natural resources by using alternative building materials and recycling construction waste rather than sending truck after truck to landfills.

It also adopts interior spaces having natural lighting and outdoor views, while a superior indoor air quality is ensured by having highly efficient heating, ventilating, and air-conditioning (HVAC) systems and low-volatile organic compound (VOC) materials like paints, flooring, and furniture, Meanwhile, it addresses the occupants who should be healthier in the environment. For office building, it potentially boots the productivity of workers and has lower overheads costs. Fig. 7.1 demonstrates some of technical considerations in green office building.

Interior Lighting: Typically, interior lighting makes up a large proportion of energy consumption of office buildings. Lighting may also generate more heats, potentially leading to more demand of air-conditioning and more energy consumption. A proper design of building orientation can effectively utilize daylight and considerably reduce artificial lighting and save energy consumption.

Orientation: Proper selection of building orientation is also useful to capture the breezes through rooftop clerestories at locations commonly subject to winds, providing cross-ventilation, and subsequently reduce energy consumption for HVAC.

Building form: A long narrow building shape may be considered in the design to maximise natural lighting and ventilation.

Windows: Openable windows and skylights enable more natural ventilation. windows with low-emission glazing minimize interior solar heat gain and glare.
Reflective surface: The use of reflective surfaces, mature trees to shade building walls and roofs on low-rise buildings may significantly reduce heat effect and minimize interior solar heat gain, especially in summer.

Green roof: It is particularly useful to create a green roof landscape with drought tolerant grasses and plants, which may lessen the heat island effect. A green roof also helps clean the air, serves as a wildlife habitat and absorbs and filters rain that would otherwise overload the storm drains and streets.

Technology: Green building technologies, including microturbines, and photovoltaic systems, reduce energy demand of grid electricity.

Water: Water-conserving irrigation systems and plumbing, waterless urinals and native and drought-tolerant landscape plants, recycled water for landscaping needs.

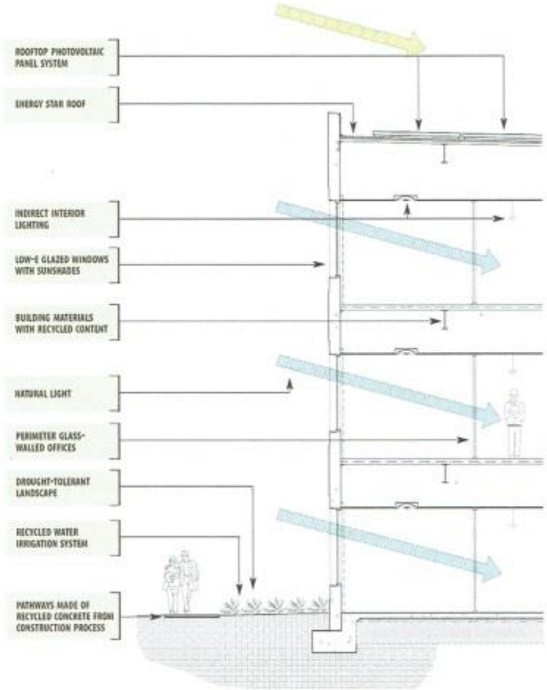


Fig. 7.1

Some design consideration in green office buildings

Recycled materials: Sustainable, nontoxic building materials are important to healthier indoor environment. These include low-and zero-VOC paints, strawboard made from wheat and linoleum flooring made from jute and linseed oil. The increase of recycled materials such as recycled carpeting and heavy steel, acoustic ceiling tiles and furniture with significant recycled content and soybean based insolation may benefit to the reduction of resource consumption and landfill. This also includes recycling construction waste. However, green building design should balance the benefit. Increase of more windows may certainly increase the use of natural sunlight, but it also reduces the degree to which exterior walls are insulated. While more solar radiation is preferred in winter, it would be avoided in summer Moreover, green building design is now considered as a process, which involves owners, architects, interior/landscape designers and engineers. Integrated building design is considered to achieve overarching building design goals in terms of high performance, low energy, sustainable buildings. It is collaborative process, looking into how the building and its systems can be integrated with supporting systems and how materials, systems and products connects, interact and affect one another.

5.3 low energy building Design

The concept of low-energy building design, developed in Europe, is generally considered to be buildings that typically consume energy in the range from 30 kWh/m² to 20 kWh/m² per annum, in comparison with the average consumption of 200-250 kWh/m² per annum. Below this, the term 'ultra-low-energy building' is often used. When net annual energy consumption turns to zero, it is known as zero-energy building design. It should be mentioned that low-energy building design is only a design that considers energy-related indicators in sustainable building design.
Low-energy buildings mainly focus on the demand side management to reduce the annual energy consumption of the building. The general approaches used for demand reduction in low-energy buildings can be categorized into the following aspects:

Use building energy simulation tools for design.
Optimize the passive solar design approaches.
Maximise the thermal performance of building envelope.
Maximise daylighting and high-efficiency lighting system.
Internal loads efficiency.

The very first approach to achieve low-energy buildings is to predict the energy consumption during the design stage. The building simulations allow the user to model the building in a computer interface and assess the impact of each decision making process on the building energy consumption. This will enable the designers to choose the appropriate construction materials, elements and the construction processes to achieve minimum energy consumption of the building. In addition, the building simulation tools allow the designers to examine the passive design concepts, such as orientation and shape of the building, windows, ventilation systems, to minimise the energy consumption. Simulation tools mainly consider the thermal balance of the buildings, considering external and internal thermal loads on building. They use complex heat transfer equations to solve the heat imbalance in a building when an external or internal thermal solicitation is expected. They are many building simulation tools available to assess the building energy consumption, particularly the operative energy consumption. Some of the widely known tools are energy plus (energy place, 2012),Trensys (Fiksel , 1995), Accurate (CSIRO) ad Design

Builder (Tronchin & Fabbri, 2008). Although the building simulation tools predict the energy consumption without much effort, the accuracy of the results should also be considered. Simulation tools require calibration, validation and verification of in-built programs that are used to solve the thermal balance algorithms. The validation can be archived by either comparing the outputs of the simulation tool with the experimental observations or benchmarking the simulation outputs with a validated simulation tool. Most of the popular simulation tools validate their in-built programs with the experimental results on a timely manner. However, consideration of new and emerging construction materials or processes, such as dynamic thermal insulation or phase change materials, requires validation of the developed thermal model since the validation has not considered these materials.

Passive solar building design techniques are the critical technology applied to the low-energy building design. It relies on natural sources of heating, cooling, lighting and ventilation. Natural resources include sunlight, wind, vegetation, etc. it also defines the energy character of the building before considering active systems to meet thermal comfort in buildings. The maximum benefits that can be obtained by passive design techniques are mainly governed by the building location/site, surroundings and the building design.

Passive solar building includes six distinct design elements as listed below (Kibert, 2016):
Building orientation and aspect ratio
Building envelope design
Daylighting strategies
Ventilation strategies
Thermal mass and insulation
Internal load reductions

5.3.1 building Orientation and Aspect Ratio

The orientation of the building plays the major role in the energy performance of buildings. Orientation of a building means the positioning in relation to the seasonal variations in the sun's path as well as prevailing wind patterns. The location of the building or local climate conditions significantly influence the building orientation and its aspect ratio. Figure 7.2 shows two houses located in different climate regions of temperature climate zone and tropical climate zone. It can be seen that the house located in temperature climate regions require more openings (windows) in the north direction (it is only applicable to southern hemisphere like Australia; in northern hemisphere, it is south direction) to receive direct solar radiation for heating in winter. Furthermore, the openings in west direction should be minimized to prevent heat gain during summer evening.

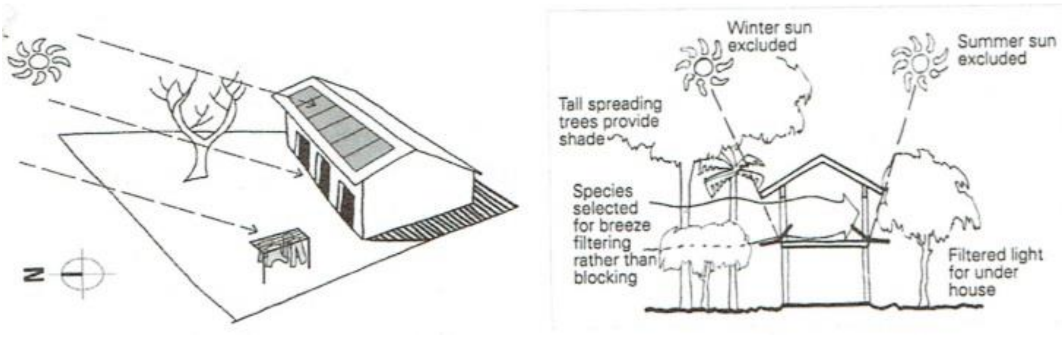


Figure 7.2

On the other hand, in tropical regions (countries close to the equator), the path of the sun changes gradually throughout the year between summer and winter. Therefore, buildings should be oriented such that the majority of the walls and windows can be easily shaded from the direct sun. depending on the building use, it may be desirable to admit some northern sun (for countries in southern hemisphere) in the winter months, which can be done by planning the width of eaves and awnings. Growing tall spreading tropical trees can be advantageous to provide shade to the building. The site conditions also have an impact on the passive design. If the site has right characteristics, good passive solar performance can be achieved with a minimal cost. For example, if the house is surrounded by tall buildings or shade-giving plants, it is necessary to choose optimum daylighting and natural ventilation strategies as discussed below.

5.3.2 Building Envelope design

The building envelope system contributes to the energy transmission through the building skin as conduction, convection and radiant heat transfer process. The major envelope surfaces are walls, windows, and roof. Efficient design and construction of buildings envelope systems could substantially reduce the energy gain into the building during summer season and energy losses during winter season. The features of an efficient building envelope systems are:

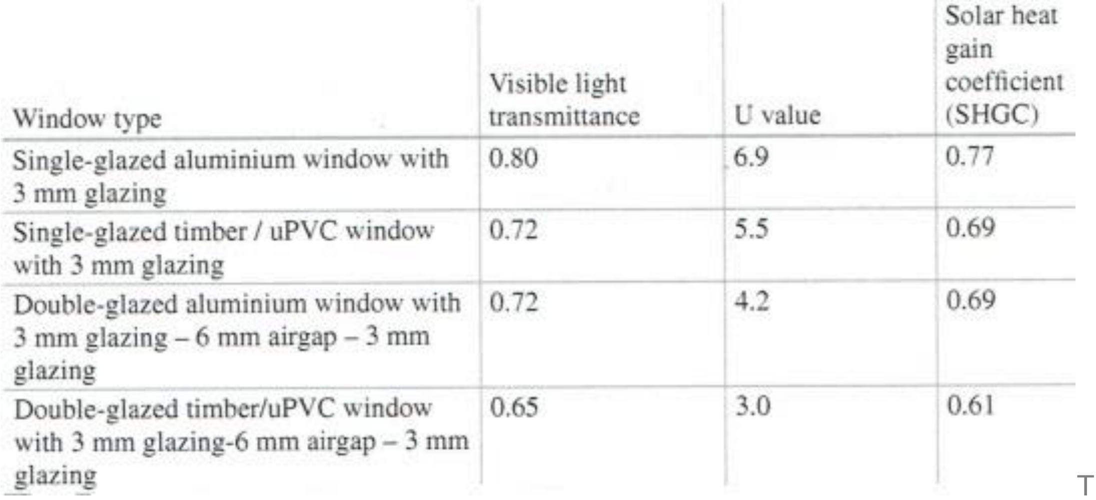
Capability to control solar heat gain into the building.
Minimise direct heat transmission into the building.
Minimise the infiltration or leakage by having a tight and thermally resistant envelope.

5.3.3 Building Envelope Design: wall system

Walls cover a large amount of building surface area and are responsible for direct heat transmission into the building. Buildings walls should be designed to have high thermal resistance and thermal mass, and their orientation significantly influences effectiveness in reducing the heat transmission into the building. The difference between thermal mass and thermal resistance is that the thermal mass has the ability to absorb and store heat energy, whereas thermal resistance delays the heat transfer through the element. Studies have reported that placing insulation materials to the exterior of the building walls and thermal mass closer to the interior would provide an effective solution for reducing the heat transmission into the building. However, it must be noted that the design of building walls also depends on local climatic conditions, and thermal simulations should be carried out to identify the most efficient wall design. For example, the countries experiencing large diurnal temperature fluctuations can take advantages of high thermal mass as they reduce the indoor temperature fluctuations by storing excess thermal energy and discharge when required. In contrast, tropical counties with low diurnal temperature variation require high thermal insulation to delay the heat penetration into the buildings. The exterior wall surface properties also play a major role in resisting or reflecting the solar thermal radiation into the building. Building walls with high roughness can reflect more heat to the surrounding as long-wave radiation and reduce the heat penetration into the building. Light-coloured surfaces also absorb less amounts of the solar radiation compared with dark-coloured surfaces.

5.3.4 Building Envelope Design: Windows

Windows are meant to allow light into the room spaces, while openable windows exchange the indoor air with outdoors. Due to the requirements of light penetration through the windows, they are designed to be transparent. The transparent nature would allow solar irradiance into the rooms and easily heats up the rooms. On the other hand, window glasses are generally thinner compared with other building elements, and therefore, thermal resistance is poor. High-performance windows should incorporate the permission of light into the structure while controlling solar heat gain and conduction energy through the assembly. The performance of window is measured by thermal conductance (U-value),solar heat gain coefficient (SHGC) and visible transmittance. SHGC is simply a measurement of the amount of solar irradiance penetrated through the glass, as a fraction of total solar irradiance penetrated through the glass, as a fraction of total solar irradiation that falls on the window surface. The lower the SHGC, the less solar heat penetrates through the glazing from the exterior to the interior. It is recommended to have high SHGC glazing for north-facing windows (for the houses located in southern hemisphere) to receive winter solar radiation into the rooms. On the other hand, west-facing windows should have low SHGC to prevent the solar energy penetration during afternoons and hot summer days. Table 7.1: shows the window glazing parameters for some of the commonly used windows in Australia. Low-emissivity glasses or applying reflective coatings to normal glasses can control the SHGC of windows; however, the effectiveness of those coatings largely depends on the thickness and reflectivity of the layers.



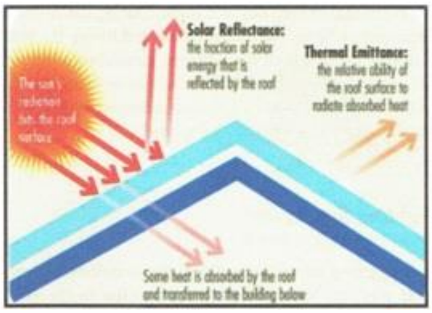
Window type	Visible light transmittance	U value	Solar heat gain coefficient (SHGC)
Single-glazed aluminium window with 3 mm glazing	0.80	6.9	0.77
Single-glazed timber / uPVC window with 3 mm glazing	0.72	5.5	0.69
Double-glazed aluminium window with 3 mm glazing – 6 mm airgap – 3 mm glazing	0.72	4.2	0.69
Double-glazed timber/uPVC window with 3 mm glazing-6 mm airgap – 3 mm glazing	0.65	3.0	0.61

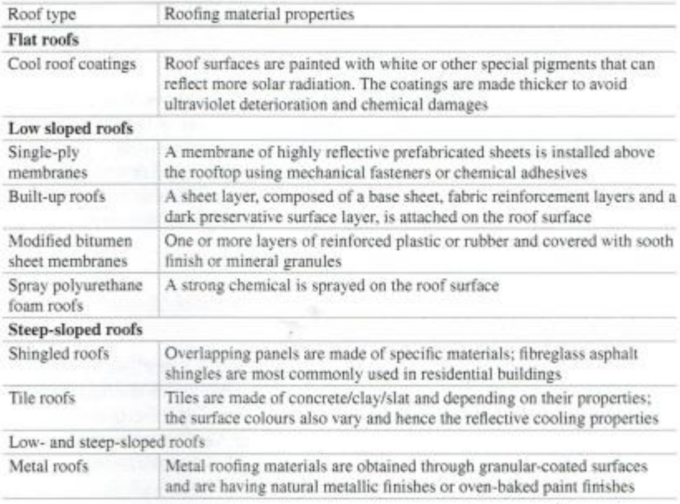
Table 7.1

5.3.5 Building envelope design: roof

Roof is a major area for heat transmission due to its generally large size and direct exposure to the sun. roof surface of the open area buildings can reach up to 83 degree C in the summer day, which not only heats up the indoor of the buildings, but substantially affects the neighbourhood as low-wave radiations. The thermal performance of building roof designs can be achieved by following physical principles as mentioned in Al-Obaidi. Reflective cooling techniques by slowing down the heat transfer through roofs.Radiative heat technique by removing unwanted heating from the building.Reflective roof designs aim at reducing the heat gains on the building roofs by carefully choosing the roof surface properties to act as a reflector of invisible electromagnetic radiations (short-wave and long-wave radiations) and as a good emitter of heat. Two key features of the reflective roofs are solar reflectance (also known as albedo effect) and thermal emittance as shown in fig. 7.3.

Albedo is a measurement used for measuring the reflectivity of the solar radiation. And a high albedo can assist in reducing the thermal loads onto the neighbourhood. Light-colour roofs have high reflectivity or albedo, and they can significantly reduce the thermal loads onto t less he neighbourhood. A study on the effect of roof surface reflectivity on the building energy consumptions reported that the high-coloured, reflective roof surfaces use 40% less energy than dark roofs. Another study conducted experiments on three identical buildings using three different coating materials and reported that the increase in surface reflectance from 32% to 61% can reduce the annual energy consumption by 116 KWh (Shen, 2011). Different Types of Reflective roofs according to the slope of the roof summarised by Urban and Roth (2010) are given in table 7.2: the radiative cooling technique utilises the emissivity characteristics of the roof surfaces to emit the energy in the form of electromagnetic radiation.





Roof type	Roofing material properties
Flat roofs	
Cool roof coatings	Roof surfaces are painted with white or other special pigments that can reflect more solar radiation. The coatings are made thicker to avoid ultraviolet deterioration and chemical damages
Low sloped roofs	
Single-ply membranes	A membrane of highly reflective prefabricated sheets is installed above the rooftop using mechanical fasteners or chemical adhesives
Built-up roofs	A sheet layer, composed of a base sheet, fabric reinforcement layers and a dark preservative surface layer, is attached on the roof surface
Modified bitumen sheet membranes	One or more layers of reinforced plastic or rubber and covered with sooth finish or mineral granules
Spray polyurethane foam roofs	A strong chemical is sprayed on the roof surface
Steep-sloped roofs	
Shingled roofs	Overlapping panels are made of specific materials; fibreglass asphalt shingles are most commonly used in residential buildings
Tile roofs	Tiles are made of concrete/clay/slat and depending on their properties; the surface colours also vary and hence the reflective cooling properties
Low- and steep-sloped roofs	
Metal roofs	Metal roofing materials are obtained through granular-coated surfaces and are having natural metallic finishes or oven-baked paint finishes

Figure 7.3 Table 7.3

Generally radiative heat flux occurs when the two surfaces are different temperatures and face each other. The radiative heat transfer occurs until an equilibrium state is reached. For buildings, the radiative cooling is based on the temperature difference between sky conditions and the building surfaces, whereas cloud cover, air humidity and pollution could reduce the cooling performances. The radiative cooling technique can be beneficial in both day and night. During the daytime, roof surfaces can absorb the excess heat from the room bellow and losing the heat through long-wave radiation during night where the ambient temperature is lower than in roof surfaces. The strategy of choosing coloured roofs as well as the lightweight structures influences the long-wave radiation emission during the night-time, in addition to the reflection of solar irradiance during daytime.

5.4 Daylight strategies

Natural light or daylighting not only supplies lights to indoor for free; they have also shown to provide physical and psychological benefits to the occupants. Almost every building can benefit from daylighting to a certain extent if proper strategies are applied in installing the daylighting devices. Some of the key considerations in daylighting are accessibility of light through windows, the selection of glazing type, optimum daylighting requirement and its position as well as automated daylight activated controls. Windows are the primary elements

to receive daylighting, and it can be achieved by poisoning windows in a perimeter wall. Roof space, core, etc. depending on the building surroundings and shading. For instance, a building in high-density urban site may not receive sufficient light to fully utilise the daylighting.
When the daylighting cannot be achieved by simple windows, skylights can be used. Skylights can admit as much as three times of amounts of lights than vertical windows of the same size and distribute the light evenly into the indoor space. They are a good alternative when the lighting on the buildings is limited or when the building is restricted by the size of windows due to privacy concerns or architectural preferences.
Figure 7.2 shows few different types of skylights available in Australia.

5.4.1 Lighting

Lighting is a major energy use in buildings, consuming the second largest share of energy use in commercial buildings. After only space heating. Lighting can readily be designed to use 25% of the energy traditionally consumed for the service (75%less), and in many cases even less.

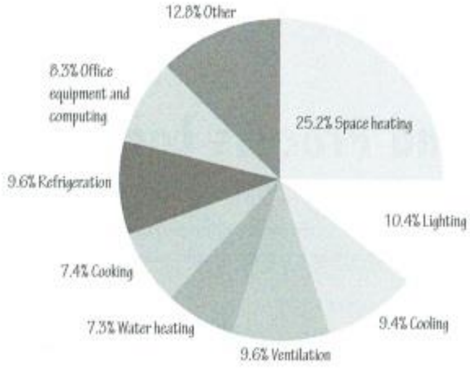


Figure 11.01

Percentage of commercial building energy use attributable to lighting.

5.4.2 Space design to minimize the need for lighting.

The need for artificial lighting has also already been minimized by intelligent space design. Referring to the earlier phases of design, if a specific building can be designed to fit within a smaller floor area, the amount of artificial light needed and, therefore, the amount of energy required to light the building will be less.
Further when a building is smaller, harvested daylight penetrates a larger fraction of the building area than it does for a larger building serving the same purpose.
Gains may also have previously been made by avoiding tall ceilings. For example, a space with 8-foot (2,440) ceilings requires 5% less artificial light to deliver the same light level than the same space with 10-foot (3,050) ceilings.
Reflective finishes may have also already been selected to minimize the need for lighting. Recall the example where only a 10% higher reflectance in the ceiling, wall and floor finishes resulted in a 13% lighting energy savings while delivering the same amount of light to a space. Savings over 30% are possible by further increasing the ceiling, wall, and floor reflectances.

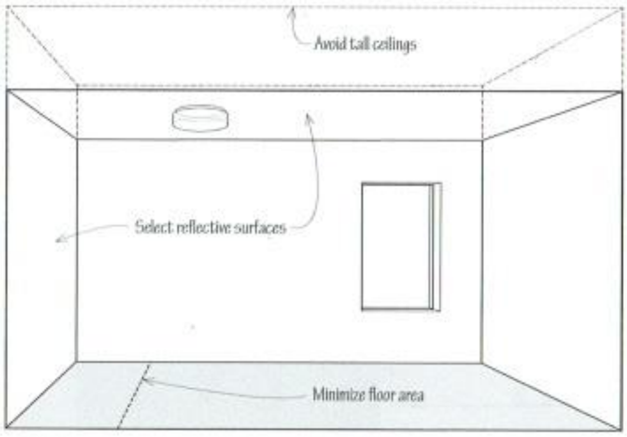


Figure 11.02

Space Design to avoid artificial lighting

5.4.3 Optimized Lighting Design

With a space designed to minimize the need for artificial lighting, we can proceed to design the lighting. For green buildings, this calls for the use of photometric calculations or computer software to examine light fixture selection and layout on a space-by-space basis. Historically, much lighting has been designed by rule of thumb, often resulting in more light than is required. Room-by-room lighting design is a best practice for green building design. Without room-by-room design, a building will likely have too much lighting; use more energy with more light fixtures than is required; and use more material with a greater amount of embodied energy than is necessary.

Example of photometric calculation

Luminaire quantity	9
Average Illuminance	55.4 foot-candles
Maximum illuminance	60.3 foot-candles
Minimum illuminance	36.2 foot-candles
Total power	291 Watts
Lighting power density	0.44 Watts per square foot

1 foot-candle=1 lumen per square foot or 10.764 lux

5.4.4 Exterior Lighting

Exterior lighting can be delivered most efficiency by using many of the same tools as interior lighting: high efficiency lighting fixtures; computerized area by area lighting design to provide safe lighting at a level no higher than needed; low high fixture mounting to bring the illumination closer and more efficiently to where it is needed; and efficient lighting controls. There are four main types of controls, each of which can be used to reduce lighting energy use, either alone or in combination: manual controls, motion sensors, photosensors, and timers.

5.4.5 Decorative Lighting

Decorative lighting merits its own discussion within the context of green buildings. Decorative lighting includes interior lighting intended to draw attention from the outdoors to the building interior; exterior lighting intended to highlight facades or other exterior elements; signage lighting; and lighting to highlight artwork or retail displays. Decorative lighting is often inefficient, although high-efficiency fixture and lamps are available, which can be controlled with high-efficiency controls.

5.4.6 Plug Loads

Plug loads are rapidly increasing cause of energy use in buildings. growth are average 3% in recent years. Miscellaneous loads are estimated to be 43% of residential building energy use and 34% of commercial building energy use. Ans as heating and cooling energy use continues to be reduced, plug loads are expected to grow above 50% of building energy use in low-energy buildings.

5.4.7 Artificial lighting sources

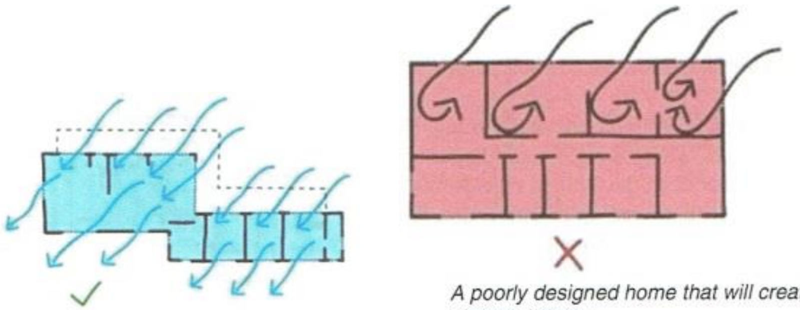
Lamps are devices that convert electrical energy into heat and light. Light sources can be divided into various types according to the physical principle by which the light is produced and their efficiency. The efficiency of a light source is defined as the relationship between the light that is emitted and the electricity that is consumed or, alternatively, the ratio of the emitted light to the heat produced. Theoretically, we could turn all of the electrical energy into light by emitting radiation with a wavelength of yellow-green light (monochromatic radiation with a wavelength of 523nm) that would be equal to 680lm/W. but the human eye is not equally sensitive to all the wavelengths that make up ‘white’ light. Therefore, the theoretical efficiency of a light source emitting only white light is just 200lm/W. for the past 100 years we have manly used incandescent lamps. But a much better lighting efficiency can be achieved with fluorescent lamps.

5.4.8 Visual comfort requirements

The demands of light comfort in indoor and outdoor areas result from the psychological and physiological needs of people. Psychological needs are satisfied if the lighting provides us with the following: A guide to our motion and orientation in space and a visual connection to our surroundings: connections to our bio-rhythms an ability to make objects recognizable in space; an ability to direct attention and help us to classify the importance of the information received by sight; an assurance of feeling of individuality with more or less illuminated parts of large spaces; a diversity of internal spheres and an absence of fear in dark spaces-where danger is normally expected.

5.5 Ventilation Strategies

Ventilation strategies provide cooling of the buildings through heat loss by exchanging the warm indoor with cooler external air. In addition to the heat loss, the ventilation improves occupant thermal comfort by increasing the evaporation from the body due to the continuous movement of indoor air. Ventilation in buildings can be achieved by active or passive methods. Passive ventilation methods include cross natural ventilation by strategically positioning windows, thermal chimney effect, Venturi effect, wind catchers, etc. active ventilation methods use the energy to mechanically force the air exchange between indoor and outdoor. Fans and dampers use electrical energy to provide mechanical ventilation in buildings. Narrow or open plan building layouts provide better cross-natural ventilation effects on building spaces as shown in fig. 7.4. they work well when there is an air-pressure differential caused by wind or breezes. However, cross-natural ventilation may not be effective in buildings with following situations:


A well designed home with single room

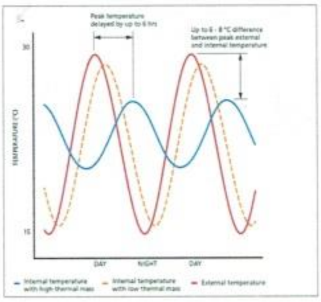
A poorly designed home that will create hot stagnant areas.

Fig.7.4

Building located in high noise, security risk and poor outdoor air quality areas, where the windows need to be closed at most.
Consecutive days of high outdoor ambient temperature
long air movement paths due to deep spaces

5.5.1 Thermal Mass and insulation

In passive solar building design, thermal masses of the building components such as walls and roof act as the thermal energy storage materials to store excess solar thermal energy and discharges when required. This helps to reduce the indoor temperature fluctuations, reducing the peak indoor temperature, and also helps to shift the peak energy demand for mechanically cooled buildings. The reduction ad shift in the peak energy demand are particularly advantageous to reduce the high demand of electricity grid during the peak times, allowing to choose a smaller capacity air-conditioning systems, and operate the air-conditioning system at an efficient mode because the peak load occurs later in the evening when the outdoor air temperature dropped from midday. Figure 7.5 shows the indoor temperature fluctuations of two cases: one with low thermal mass and the other with high thermal mass. It can be seen that the high thermal mass significantly reduces the diurnal temperature fluctuations and has high peak load shifting. High thermal mass is required for temperature climates where a significant diurnal temperature variation is experienced. The common insulation material applications in buildings are walls, ceiling, roof, and underfloor insulations. There are generally two types of insulation products available: bulk insulation and reflective insulation.




Time lag figures for various materials

Material thickness (mm)	Time lag (hours)
Double brick (220)	6.2
Concrete (250)	6.9
Autoclaved aerated concrete (200)	7.0
Mud brick/adobe (250)	9.2
Rammed earth (250)	10.3
Compressed earth blocks (250)	10.5

figure 7.5

A high-performance building component is characterised by its thermal storage medium and insulation layers as well as their distribution or relative locations. A case study on different construction types of exterior wall system was conduced using building simulations to understand the best combination or distribution of thermal mass and insulation in building walls. Four different wall construction types as shown in Fig. 7.6 are considered for the analysis.

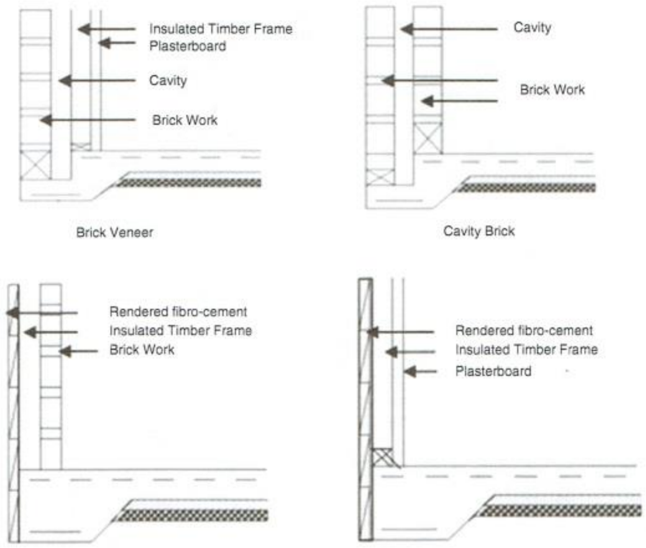


Fig. 7.6

5.6 Sustainable Design, construction, and operation

Sustainability and building

Buildings are major consumers of energy and resources for their construction, maintenance, and operation. The resources are natural per manufactured building materials that have also consumed energy during processing and transportation. The principle construction techniques use materials that require variable amounts of processing. For example, stone may be used for building foundations, walls and paving, or may be crushed to produce graved or sand, to be added in concrete mix. Stone is also used as the basic material for manufacturing cement. Energy is consumed at all stages of the construction process, from the extraction of materials from the natural environment, to processing and transportation to the building site, as well as during the construction phase itself. Large amounts of energy are consumed during the lifetime of the building. Energy consumption ends with the demolition and disposal of building materials back to nature. Building, therefore, consume materials and energy during three distinct periods of their life:

The first is the manufacturing-construction period, during which materials are produced from the natural environment, processed, or manufactured (energy used for this process is termed embodied energy), and transported to the building site (using grey energy). This period ends with the construction stage of the building (energy used for this process is termed induced energy).

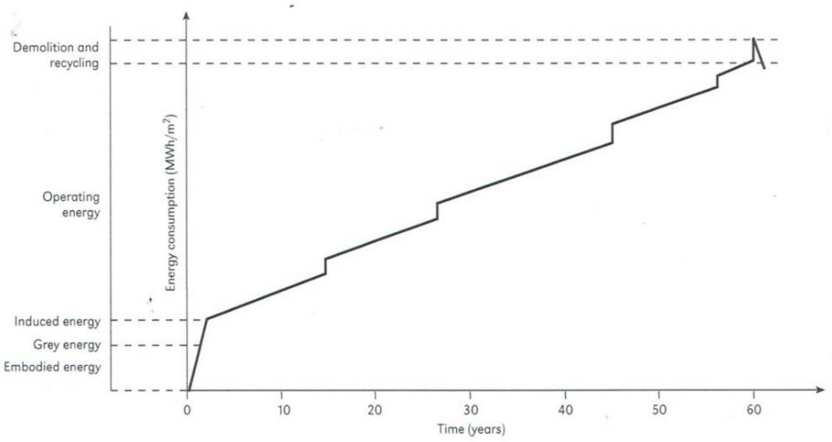


Figure 4.1

The second period is the useful life of the building, during which it uses energy (operating energy) for its operation. During this period, energy and resources are also used for the maintenance of the building. It should be noted that this is the most significant period of building's life with regard to its consumption of energy, and it should equally be a period of improving energy consumption.

The third period is the demolition and recycling, during which a building has completed its useful life, and energy will be used for its demolition and recycling or disposal of its materials.

5.6.1 Environmental consequences of buildings

The brief description of a building's life cycle demonstrates that the natural environment is affected in two ways. The first is the fact that all buildings need and, indeed, use natural resources in the form of building materials energy. This, as an environmental consequence, way be described as the effect of environmental consumption and should be the basic concern of sustainable design. For the construction process, environmental consumption comprises building materials on the one hand and non-renewable energy resources on the other:

The second environmental consequence relates to the use of non-renewable energy in buildings and may be described as environmental deterioration. All use of non-renewable (or environmental) energy will affect the environment as a result of pollution. Greenhouse gases, (principally carbon dioxide, or CO^2) are produced as a result of burning hydrocarbons. Environmental degradation also occurs as a result of the manufacturing process, which in this case relates to the production of building materials and the disposal of demolition products.

5.6.2 The global, local and indoor environment

In order to control the environmental deterioration that results from building process, we have to consider the environmental consequences in more detail. Building materials are defined by their environmental behaviour. A material used in a building may directly affect the health of its inhabitants. The same material during its manufacture may have contributed in a number of ways towards the degradation of the environment in the area where it was manufactured. Finally, this material may be responsible for climatic changes due to the large amounts of greenhouse gases emitted to the atmosphere during its manufacture. In order to control all environmental consequences that result from the building cycle, we have to measure environmental impacts according to three different scales. During the life cycle of buildings, solid waste and air pollution are produced. The production of pollution such as CO^2 augments the atmospheric content of CO^2, contributing to the global greenhouse effect. The same happens with the use of chlorofluorocarbons (CFCs) and other gases that escape national borders with the air movement around the globe, affect the globe climate by depleting the ozone layer and, consequently, cause the global environment to deteriorate. The use of materials and energy contributes to local environmental deterioration, with solid waste and air pollution, which affects the local atmosphere of an area, as well as the nature environment. The second scale of control is the local environment. The construction of modern buildings often includes new technique and materials that have not been adequately tested. The extended use of buildings, combined with inadequate ventilation, brings the inhabitants into contact with an atmosphere of dubious quality, which may contain, besides pathogenic micro-organisms, carcinogenic and toxic substances in high concentrations. The exposure of inhabitants to such an internal atmosphere may affect their health. It is imperative, therefore, to control the indoor environment of a building. As a result, the control of all environmental consequences of the building cycle should be achieved according to three environmental scales:

The global environmental, for environmental consequences on a global scale.

The local environmental, for environmental consequences on a local scale.

The indoor environmental, for environmental consequences on an indoor scale.

5.7 Sustainable construction techniques and materials

The aim of this section is to define what sustainable construction techniques and materials are and to set forth criteria for their environmental evaluation. A construction technique is the entire procedure of using one or several building materials. In this sense, stonewall masonry is a technique that uses stone as the principle material during construction; but it also uses many kinds of mortars as binding agents and for different types of joint finishing. A construction technique, therefore, consists of the materials used, their joining together and finishing, and the environmental consequences of extracting them from the natural environment, processing them and transporting them to the site. The natural resources, the method used to extract them from the environment, their processing and the way in which they were used during construction define the environmental consequences of the technique. Obviously, to evaluate this, we should assess materials and processes that constitute a technique, and try to minimize detrimental environmental impacts. A construction technique, in order to be sustainable, should minimize environmental consumption and deterioration should be tested according to its global, local and indoor impacts upon the environment.

Several references deal with materials and construction methods for specific countries within the European Union (EU). In particular, the Handbook of Sustainable Building: An environmental Preference Method for Selection of Materials for Use in Construction and Refurbishment (Anink 1996) covers techniques and materials (encountered primarily in the Netherlands). In order to overcome the lack of ready-made evaluation methods, one can use simple rules for selecting environmentally friendly or sustainable building materials. Materials that confirm to the majority of the following rules are preferable.

Use local materials

Its possible to minimize transport energy costs by selecting local building materials. As most building materials are heavy to transport and handle, the energy savings are considerable (conversely, the associated pollution generation of transporting materials long distances is significant).

Use materials in abundance

Although this rule sounds like common sense, it is important to determine the extent of what is considered to be abundant. The use of non-renewable materials has to be related to the degradation of the extraction site. Problems usually arise due to large-scale extraction to satisfy global demand, such as in the case of exports.

Use naturally renewable materials

The use of materials according to the pace in which they are naturally renewed is an important rule for supporting sustainability.

Use naturally materials with low embodied energy

Energy is consumed during all stages of building material production. The amount of energy spent is embodied within the material. Consequently, reduced overall energy consumption can be achieved by selecting materials with low embodied energy.

Use materials that are proven not to create health problems.

Sick building syndrome is, to some extent, caused by materials that emit odours, gases, chemicals, or fibres. Considering that reduced ventilation rates are needed to save energy, it is imperative to select building materials that do not degrade the indoor environment.

Reuse building materials

Reusing building materials provides a multitude of benefits. Degradation of the material extraction site is reduced, less landfill volume is occupied, and energy for the production of new materials is saved, the designer can facilitate the future reuse of a building’s materials by considering this target during the design stage of the building.

Chapter 6

6. Zero – Energy/Zero-Carbon Design

The concept of Zero-Energy design or zero-Carbon design has gained a significant attention in the last decade, and it is no longer perceived as a concept with more and more demonstration projects that have been shown in the recent years. Figure 7.11 shows the number of ZEBs around the world with their corresponding climate types. More than 280 demonstration projects have been implemented around the world with their ongoing monitoring of the performances. Before moving into details, it is necessary to understand the meaning of a ZEB.

Zero-energy building or Zero-Carbon building is a complex concept that considers multiple parameters/metrics to assess the zero design, and based on the metric used, the definitions also vary. A very simple diagram illustrating on how the zero-carbon design is achieved is shown in Fig. 7.12.

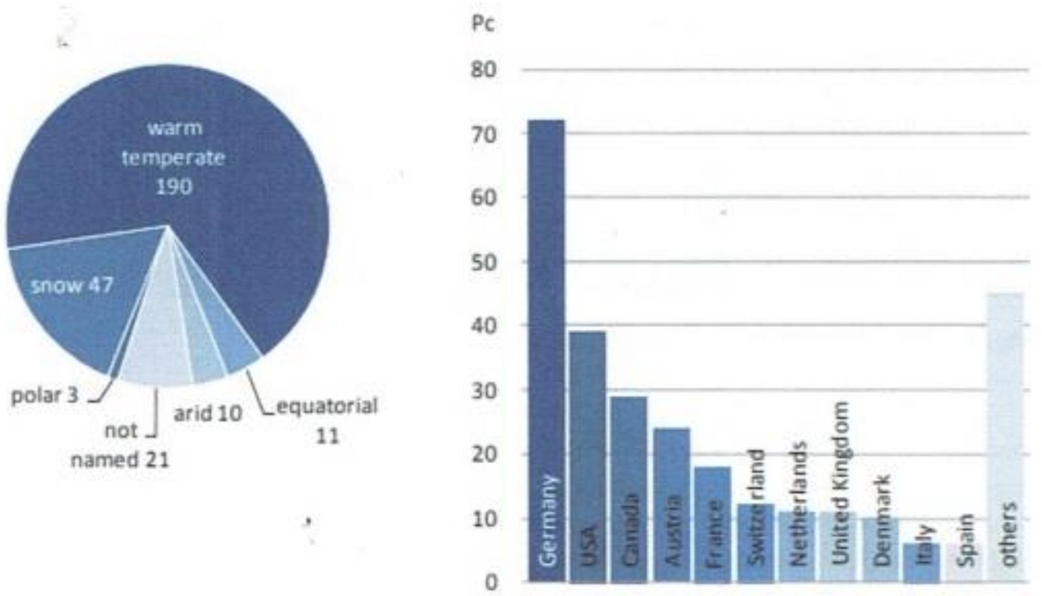


Fig. 7.11

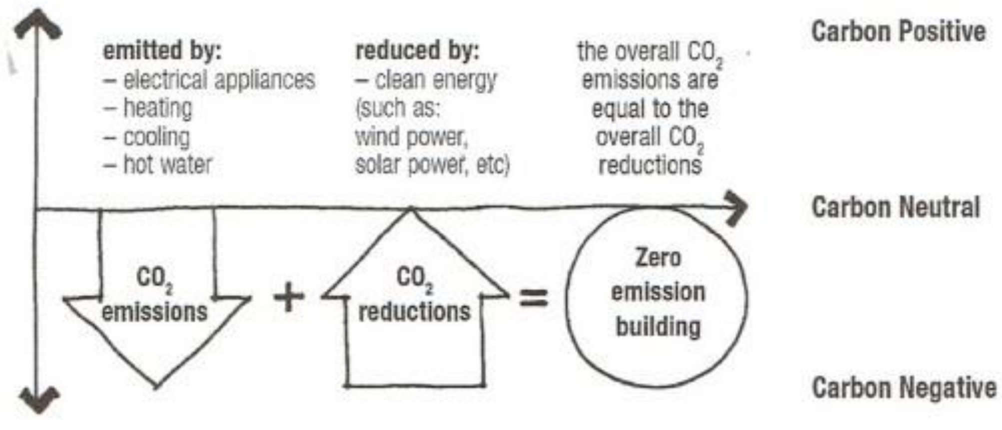


Figure 7.12

Here carbon can be replaced by energy to attain the zero-energy design. In any case, the zero-energy/zero-carbon design is a way of balancing the energy consumption of the building with same or more amount of green energy. Although this seems a straightforward assessment, there are many parameters that vary and the corresponding definitions of zero design also vary. The way of assessing zero design can be different by the consideration of:

Metric of the balance: the metric used to assess the ZEB can be end-use energy, CO^2 emission, CO^2 -equivalent emission, energy cost, exergy, etc.

The type of energy used for the analysis: the demand type that requires balancing using renewable energy can be thermal energy for HVAC operation, operative energy or life energy including embodied energy.

The balancing period: the period of time over the energy consumption is balanced using the renewable energy. The period can be at all times, annually or lifespan of the building. The type of energy balance: this criterion is relevant to the grid connected ZEBs as to choose between two possibilities: (1) the energy use of the building is balanced by the renewable energy generation or (2) the energy delivered to the building is balanced by the energy feed into the grid. The main difference between two choices is that the first balance mechanism should be done during the design phase of the building and second mechanism in the operational phase.

The renewable energy option: the green energy for balancing the building energy consumption can be green energy purchased from grid, off-site renewable energy generation or on-site renewable energy generation. Figure 7.13 shows the different types of renewable energy systems considered for zero design.

Connection to the energy infrastructure: depending on whether the building is connected to the grid or not, the ZEBs varies as on-grid ZEB or off-grid ZEB. Both on-grid and off-grid ZEBs can perform absolute ZEBs or net ZEBs.

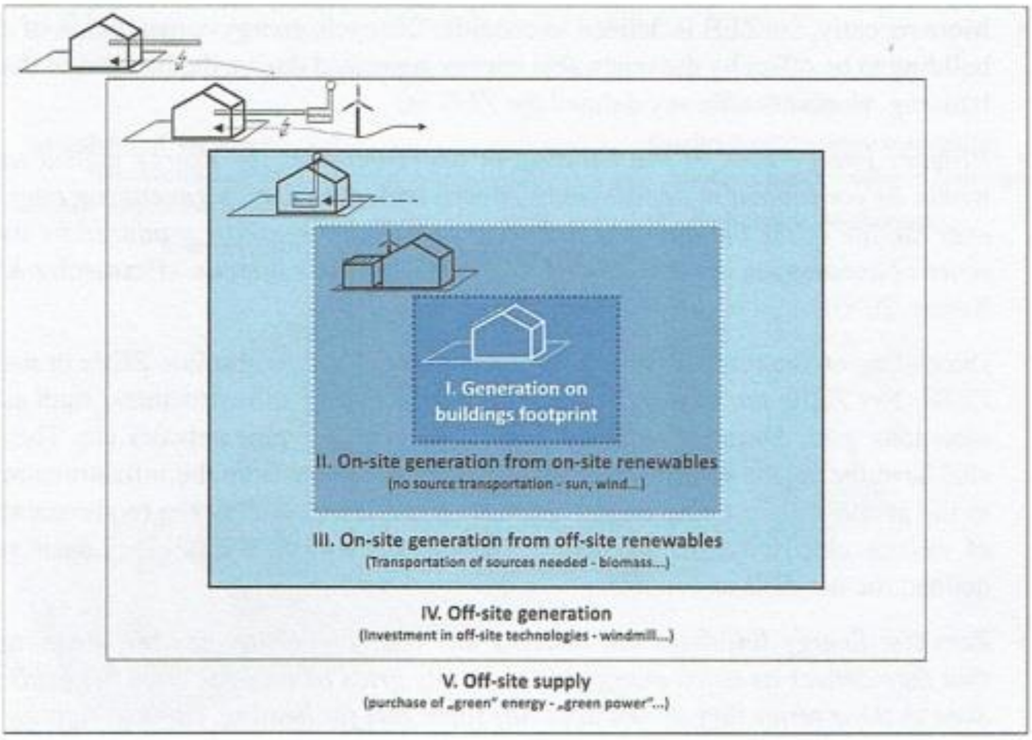


Figure 7.14

Table 7.4 summarises the different criteria for defining a ZEB using the above-mentioned factors. Based on the chosen criteria, the definition of ZEB also varies. The initial attempts towards zero development were focused on thermal energy demands during the annual operation of buildings.

Table 7.4 Metrics of balancing in ZEB

Metric of balance	Demand type	Period of balance	Type of energy use	connection to grid
Carbon emission	Thermal energy	At all times	Green energy	Off-grid
Energy	Operative energy	Annually	Off-side renewable Energy	On-grid
Energy cost	Life Cycle energy	Lifespan	On-site renewable energy	

More precisely, the annual thermal energy demands for space heating, and hot water supply is required to be offset by the renewable energy generation during the year. Esbensen and Korsgaard defined the zero-energy house as:

Zero energy house is dimensioned to be self-sufficient in space heating and hot-water supply during normal climatic conditions. (Esbensen & Korsgaard, 1977).

Later, the demand type was extended to the annual electricity consumption of the house including, space heating/cooling, hot water supply and appliances energy consumption. Gilijamse defined the ZEB as following:

A zero-energy house is defined as a house where no fossil fuels are consumed, and annual electricity consumption equals annual electricity production. (Gilijames & Boonstra, 1995).

More recently, the ZEB is defined to consider life cycle energy consumption of a building to be offset by the renewable energy generated during the lifetime of the building. Hermandez Kenny defined the ZEB as:

Primary energy used in the building in operation plus the energy embodied within its constituent materials and systems including energy generating ones, over the life of the building is equal to or less than the energy produced by its renewable energy systems within the building over their lifetime. (Hernandez & Kenny, 2010).

Depending on the time of balance, ZEBs can be defined as absolute ZEBs or net ZEBs. Net ZEBs are engaged with one or more energy infrastructures, such as electricity grid, district heating and cooling system, gas pipe network etc. they also have the capability of both supplying excess energy from the infrastructure to the grid and purchasing energy from the grid, thus avoiding the requirement of on-site electricity storage (Anna Joanna Marszal). Laustsen defined the net ZEB as follows:

Zero Net Energy Buildings are building that over a year are neutral, meaning that they deliver as much energy to the supply grids as they use from the grids. Seen in these terms they do not need any fossil fuel for heating. Cooling, lighting or other energy uses although they sometimes draw energy from the grid. (Laustsen, 2008; A.J. Marzal 2011).

The stand-alone ZEB or absolute ZEB is another form of achieving zero energy in a building without consuming the electricity from grid. They entirely rely on the generation and storage of energy from the renewable energy systems. Laustsen defines the stand-alone ZEB as:

Zero Stand Alone Buildings are buildings that do not require connection to the grid or only as a backup. Standalone buildings can autonomously supply them selves with energy, as they have the capacity to store energy for night-time or wintertime use. Laustsen (2008).

Stand-alone ZEBs are mainly considered for rural/remote areas where the connection to energy infrastructure is nearly impossible or incurs huge cost. They also require different forms of renewable energy systems as one form does not meet the required energy demand due to climate uncertainty. For instance, if the building is relied on solar photovoltaics (PVs) as the primary energy source and there is no enough sunlight for many consecutive days, the other forms of renewable energy systems are required. The limitations of stand-alone ZEBS are the requirements of large storage capacity, backup generators and energy losses during the storage and conversation back to the usage as well as the oversized renewable energy-producing system to meet the peak energy demands. Figure 7.14 shows the main aspects of a ZEB as the demand side management to reduce the energy consumption of the building followed by the renewable energy generation to meet the minimized energy consumption of the building. For example, choosing the airtight super-insulated envelope, solar shading, ventilated sunspace and green roof are means of reducing heating/cooling energy demand of the building.

Figure 7.14

Figure 7.15

High-rating appliances reduce the internal heat gains and energy consumption due to appliances. Meanwhile, solar thermal hot water, photovoltaic array and wind turbine are to generate the renewable energy supply to the buildings. Achieving the ZEB in an urban residential or commercial building is quite challenging as the site area and the technologies are limited. Figure 7.15 shows few opportunities of urban ZEB designs. Due to the very limited land size, the rooftop gardens can be advantageous to save space as well as to improve the energy efficiency of the building. Heating and cooling of buildings contribute to more than half of the operative energy consumption, and having a pallet boiler stack using wood as fuel can substantially reduce the heating energy demand of the house during winter. Sedum carports are another example of incorporating green roof in the building site.

Another way of implementing ZEB is by refurbishing the existing building to meet the requirements of zero-energy design. This is particularly important as the existing buildings contribute approximately 98%of the Australian housing stock and, thus, has a great potential for improvements. Also, refurbishing the existing buildings can reduce the resource consumption for new builds and waste generated during the demolition of the existing buildings. However, the refurbishment to meet the zero-energy design is much more challenging task than the construction of a new building due to a number of obstacles that significantly can narrow down the possible technical solutions especially in the dense city area or for multi-storey buildings. Moreover, detached buildings also have challenges due to their poor design to have limited passive design opportunities. For instance, the existing houses may have poor orientation of the building that cannot be altered during the refurbishment. Furthermore, the building context and its location do not allow to design the building only with PV system-based renewable energy source as the capacity may exceed the possible installation coverage area. Therefore, additional renewable energy systems such as wind turbines and green energy purchase from grid should be considered. Another important aspect of ZED in existing houses is the balancing period. Often the life cycle of the building cannot be considered for ZED in existing buildings because very limited data are available on the embodied energy and embodied carbon of materials used in the old building. Also, the construction process may have been conduced in an inefficient way, and the data are insufficient. It is possible to consider the balancing period of annual zero-energy design. This can be achieved by balancing the annual energy consumption of the building using the renewable energy generated during the same building. Therefore, it can be concluded that ZEB concept should be different for existing and newly constructed buildings in order to make it feasible for both cases.

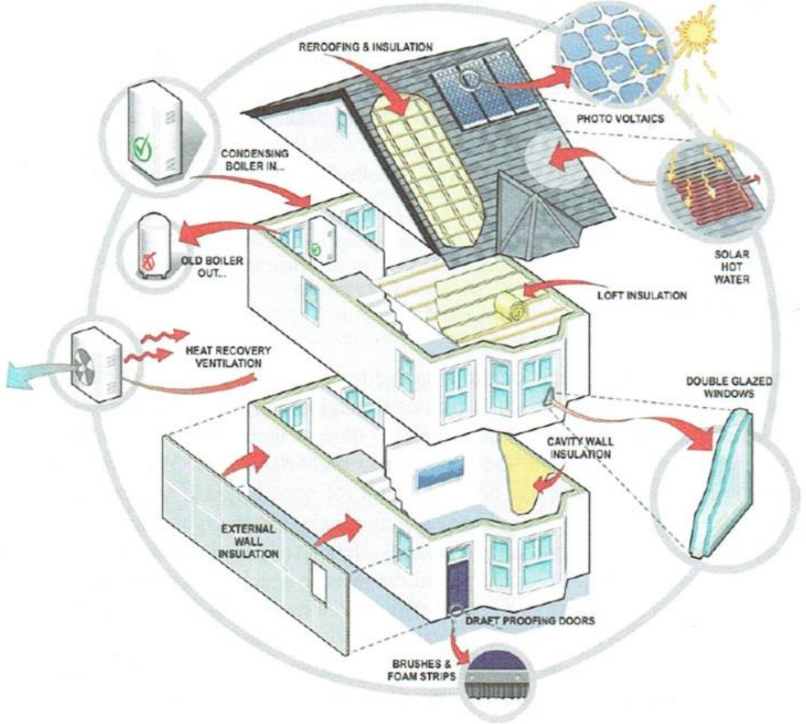


Figure 7.16

Figure 7.16 shows the opportunities of ZED in existing buildings with the consideration of various demand side strategies and renewable energy generation technologies. Some of the demand side management strategies are:

Increasing external wall insulation and cavity wall insulations
Adding loft insulation to the ceiling and high reflective insulation for roofing
Double-glazed windows for maximum protection of heat loss through glazing
Replacing old inefficient boilers with condensing boilers
Heat recovery ventilation systems to prevent heat loss while achieving the adequate ventilation for the building
Draft proofing doors and foam strips installation for gaps to prevent the heat loss due to infiltration/leaking.

6.1 Schematic Design of Net-Zero Energy Buildings (case studies)

Net-zero buildings tend to be all-electric, as we seek to reduce or eliminate the use of fossil fuels. Net energy usage, after renewable are accounted for, is zero or loss. Energy usage, before renewables are accounted for, more strongly depends on the type of building than the climate. Envelope improvements tend to be good enough that usage is dominated not by heating or cooling, but by plug and process loads. For example, a sample of net-zero office building in the U.S. was found to have an average before-renewables energy usage of 9.7 KWh/SF/year, and rising as high as 91 KWh/SF/year, whereas a variety of other buildings (public assembly, education, multifamily, other) averaged 6.7 KWh/SF/year and did not exceed 50 KWh/SF/year.

The substantial energy use of office equipment clearly shows up in net-zero energy buildings. The survey did not include any traditionally higher-energy use buildings, such as restaurants, labs, or industrial buildings, and for which energy use of 50 KWh/SF/year and higher may well be common, even in net-zero energy buildings. In schematic design, begin with an estimate of the per-unit-area annual energy use. From the above examples, in the U.S., we might assume 10 KW/h/SF/year for office buildings and 7 KWh/SF/year for a variety of buildings of lower energy intensity. Estimates may also come from early computer models. It is important to emphasize that these values are for highly efficient buildings. While they are starting points for this discussion, to get to this; level of efficiency requires substantial energy improvements over code-compliant buildings.

Once the per-unit area energy use of a building has been estimated, we can multiply this by the building area to obtain the projected building annual electricity use in KWh/year. Add any projected use for electric vehicle (EV) charges, if you are seeking to cover this use with the renewable energy. Even though EV electricity use is not typically included in accounting for net-Zero building certification. For example, a 20,000 SF high-efficiency office building using 10 KWh/SF/year is projected to have a total energy use of 200,000 KWh/year, before renewables are accounted for. From the solar insolation map chapter 2, obtain anticipated solar production in KWh/KW. For example, from the map, a solar photovoltaic system in Atlanta is expected to generate approximately 1500 KWh/KW per year. Then, divide the projected annual energy use in KWh/year by the solar KW. For the office building in the above example, which is located in atlanta and uses 200,000 KWh/year, the required solar photovoltaic system size is 200,00/1500=133 KW.

Once the required solar KW is known, the number of solar panels can be calculated. A typical 65” residential solar panel produces 285 watts. Or 0.285 KW. High efficiency panels produce as much as 370 watts, or 0.37 KW. Divide the required KW by the panel production (either 0.285 KW for a typical panel or 0.37 KW for a high-efficiency panel) to calculate how many panels are needed. Commercial panels are larger, in sizes such as 77”x36” or larger, with outputs in the 335-375 watts range and higher. For the above example, using a 350-watt (0.35 KW) panel, the number of panels required is 133/0.35=380 panels. A persistent question is: “if taller buildings have less roof area on which to place a solar energy system, relative to the building size, how many stories can a building be and still be fully served by a roof-mounted solar energy system?” in the above example, assuming 50 SF of flat roof is required for each KW of solar photovoltaic system, the roof area required is 133 KWx50 SF per KW, or 6650 SF. If the building is two stories high, the roof is 10,000 SF, and the required panels can readily be accommodated. If the building is three stories high, the roof area is 6667 SF, and the required panels cannot be accommodated with enough room for the required clearance around the array.

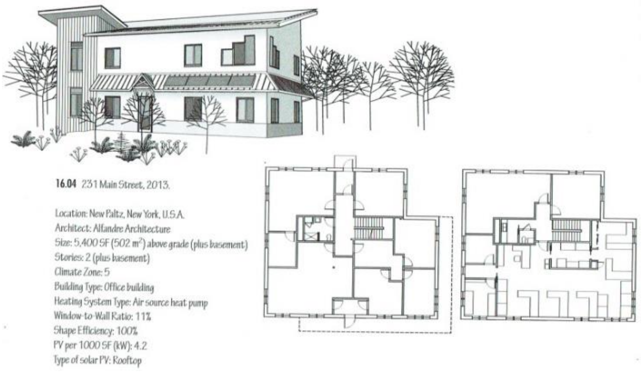
Depending on building energy use, solar insolation for a particular location, and the efficiency of solar panels, two story buildings can typically be net-zero with a roof-mounted on-site solar photovoltaic system, while net-zero buildings three stories and higher are possible in some cases. Using a shed roof structure to maximize solar output can often allow an extra story and still be net-zero. Finding ways to fit more solar energy systems on buildings while continuing to reduce energy use in the buildings, thereby allowing higher multi-story buildings with on-site renewable energy, is a next frontier in green building design.

6.2 Different Net-Zero Energy Approaches

Renewable Versus Efficiency

In designing a net-zero energy building, there are trade-offs between reducing energy loads and adding renewables. We can readily design a net-zero building that complies with the energy code, but does not exceed the code in energy efficiency, just by adding enough renewable energy, such as solar photovoltaics. Or we can alternatively design a net-zero building by adding thermal insulation, high-efficiency lighting, high-efficiency heating/cooling systems, and other energy improvements, and thereby reduce the required renewable energy.

Interestingly, for a given building size and shape, adding energy improvements (such as adding thermal insulation), and reducing the size of renewables (and reducing heating/cooling capacity) typically results in a net increase in construction cost. The current cost of solar photovoltaics is sufficiently low, even without incentives, and the energy code is sufficiently good, that the added cost of energy improvements is typically more than the construction cost savings in installing solar energy systems. Even though adding energy improvements is more costly than adding renewables, there are still good reasons to add energy improvements. If a renewable energy system ever fails, a more efficient building will use less energy than a building that just complies with the energy code. And if a heating or cooling system is ever unavailable (for example, during a power outage), a more efficient building will stay safer and remain comfortable for longer than a just-code compliant building.



16.04 231 Main Street, 2013.

Location: New Paltz, New York, U.S.A.
Architect: Alfandre Architecture
Size: 5,400 SF (502 m^2) above grade (plus basement)
Stories: 2 (plus basement)
Climate Zone: 5
Building Type: Office building
Heating System Type: Air source heat pump
Window-to-Wall Ratio: 11%
Shape Efficiency: 100%
PV per 1000 SF (kW): 4.2
Type of solar PV: Rooftop

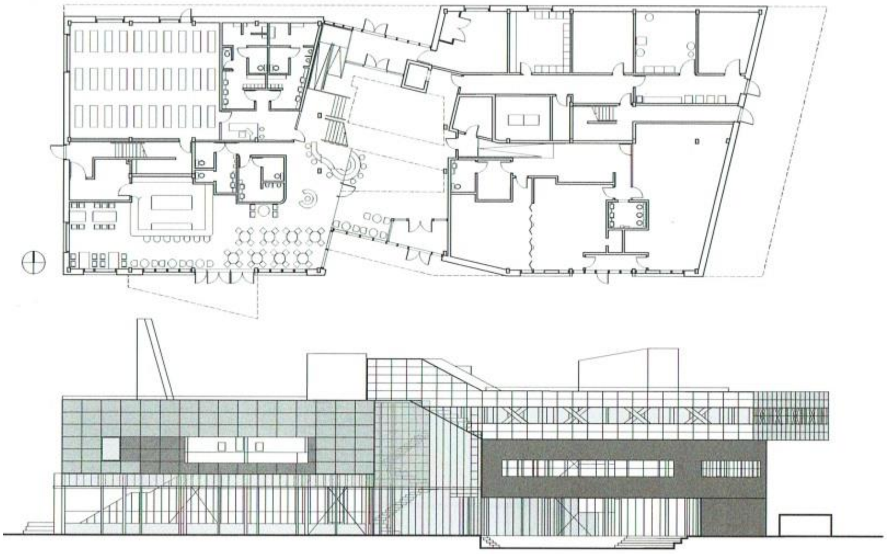
Reducing loads by reducing building size or simplifying building shape will always reduce construction cost in all major energy elements of the building: envelope, heating/cooling system, and renewables. One estimate indicates that a 105-15% reduction in building size and a similar simplification in building shape will fully offset the added cost of renewables required to deliver a net-zero energy building. Even for a building that otherwise just complies with the energy code. In other words, a smaller and simpler building can deliver net-zero performance at no added cost, relative to a larger and more complex-shaped building that just complies with the energy code.

6.3 Demonstration Versus Affordable

Another important decision to make early on in building design is whether the primary goal is constructing a demonstration building or one that is affordable. In the early years of net-zero energy buildings, demonstrating new strategies has been a major focus of green design and construction. Many of these earlier buildings focused on demonstration and did not spare construction costs in doing so. There will always be a need for demonstrations as new energy strategies are developed. However, there is an urgent emerging need for net-zero energy buildings that are affordable and are replicable in their strategies.

The strategies for demonstration buildings are often different than those for affordable buildings. Moving forward, we expect demonstration buildings will be evaluating strategies for such elements as energy storage, low embodied energy materials, optimized plug and process load controls, building-integrated renewable energy to reach net-zero with medium-rise and high-rise buildings, and more. On the other hand, affordable buildings can reliably look to already-proven strategies, such as shape efficiency, modest building size, efficient window sizing and placement, using reflective finishes to reduce artificial lighting, high efficiency lighting and controls, efficient water fixtures, low-carbon heating and cooling, continuous insulation, thermal zoning, bringing heating and cooling systems within the thermal envelope, high-efficiency appliances, and the like.

Demonstration and affordability are not always mutually exclusive. For example, it is obviously possible to design a demonstration model of an affordable net-zero energy building. But in establishing project goals, it is nonetheless instructive to decide early on whether the focus should be on demonstrating advanced strategies or whether the focus should be affordability.



Mosaic Centre for Conscious Community and commerce, 2015
Location: Edmontton, alberta, Canada
Architect: Vedran Skkopac, Manasc Issac Architects
Size: 30,000 SF (2,787 m^2) Stories: 3 climate zone:7 Building Type: Office building
Heating System Type: Ground source heat pump Window-to-Wall Ratio: 38%
Shape Efficiency: 66% PV per 1000 SF (KW): 7.1 Type of Solar PV: Rooftop

Carbon Absorption/Sequestration

Can on-site vegetation be used to absorb carbon and offset some or all of the carbon emissions from a building? For example, does a green roof substantially offset the carbon emitted from a building's use of energy? How about lawn or trees?
A highly efficient all-electric building, using 7 KWh/SF/year of electric energy, emits approximately 6 pounds of CO^2 equivalent emissions per square foot of building per year (30 kg CO^2/m^2/year). A typical green roof absorbs only 0.5 lb CO^2 /SF/year (2.5kg CO^2 / m^2/year), not including the energy required for planting the green roof or for maintenance. Trees only absorb approximately 0.1 lb CO^2 /SF/year (0.5kg CO^2 / m^2/year). Lawn grass only absorbs 0.003 lb CO^2 /SF/year (0.15kg CO^2 / m^2/year), after energy required for maintenance is subtracted. So, green roofs or site vegetation can unfortunately offset very little of the carbon emissions of an efficient building. And in any such calculations, the displacement of any on-site vegetation that is removed for construction should be accounted for. Obviously, any vegetation will help, but it cannot be counted on for substantial reductions in carbon emissions.

Cautions

In designing net-zero energy buildings, it is important to recognize unpredictable areas of design, construction, and operation. Although we can predict such energy loads as heat loss and gain through walls and windows reasonably accurately, we cannot readily account for a variety of other factors. These include but are not limited to:

Behavioural influences on heating and cooling, such as the setting of indoor temperatures and the number of hours that lighting is kept on by users.

Unexpected loads, such as unpredictable air leakage due to a failure in a building envelope. Plugs and process loads (PPL), many of which are changing rapidly over time.

Outside-building loads, such as electric vehicle charges.

Building failures, such as thermal bridging or infiltration that slips through the design/construction/inspection process. Changes in building use and energy consumption over time.

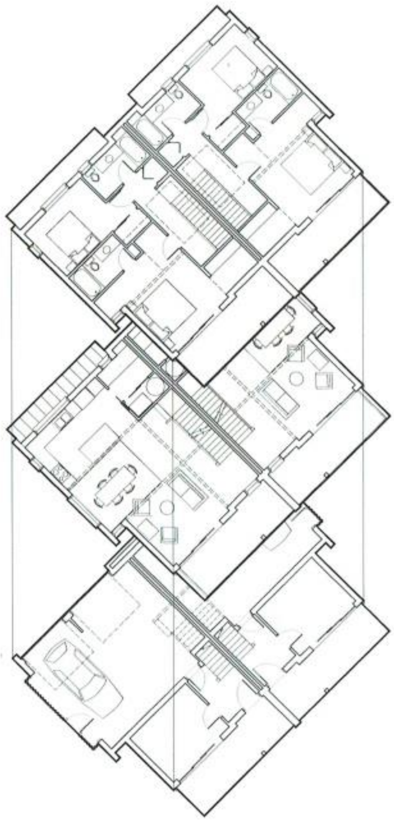
As a result, if there is a strong interest in a building meeting a net-zero energy goal, it is prudent to allow for some unpredictability in energy use, and so to select the renewable energy system with an allowance for unexpected energy use.

6.4 Discussion of case Studies

Among a small sample of widely different net-zero buildings from around the world shown in this chapter, can be a few observations.

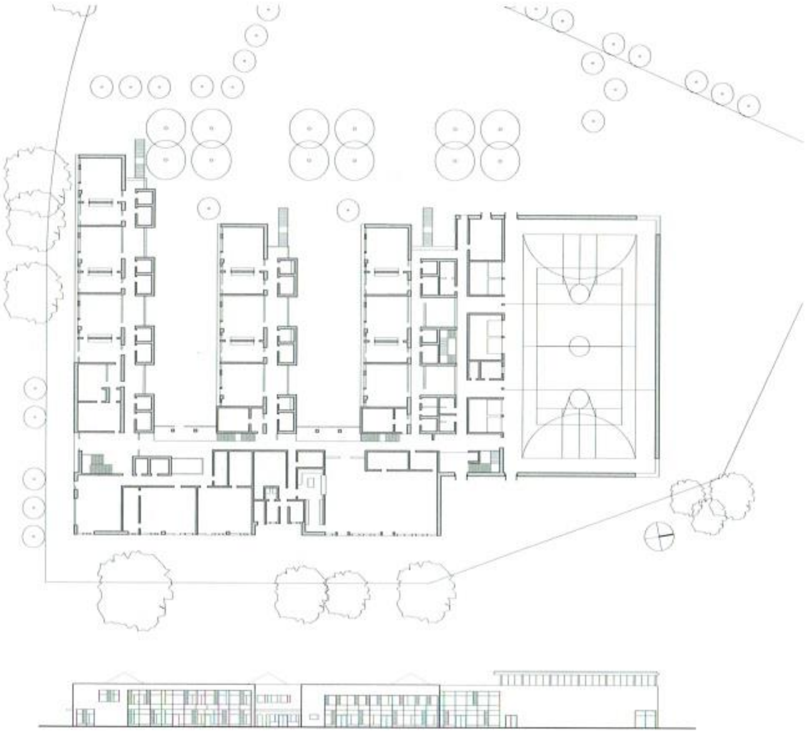
Most of these buildings use heat pumps. One building uses wood pellets for heat and one solar thermal energy. Efficiency ground source heat pumps are predominant, but there are still several net-zero buildings among these case studies that use air source pump.

The amount of solar energy required ranges from 0.7 to 7.1 KW per 1000 SF ($93m^2$), averaging 3.8 KW/1000 SF. The two outliers requiring very little solar energy (bellow 1 KW/1000 SF) are a school in Germany that uses wood pellets for both heat and to generate electricity and a building in India that likely requires little heat and that uses passive cooling strategies. If we drop the outliers, the average solar energy required is 4.7 KW/1000 SF. The shape efficiency ranges from 47% to 100%, averaging 73%. In general, these net-zero buildings have more efficient shapes than traditionally designed buildings. They have minimized surface area (walls plus roof) per unit of floor area and so have reduced both energy use and construction cost. Window-to-wall ratios ranges from 9%, averaging 26%. The majority have ratios bellow 20%. Again, they have typically reduced both energy use and construction cost in this way. And the case studies show great diversity of energy strategies within a range of architectural styles and choices to meet their proven net-zero design and performance.



zHomes, 2011

Location: Issaquah, Washington, USA
Architect: David Vandervort
Size: 13,400 SF (1.245m²)
Stories: 3 Climate Zone: 4
Building Type: multifamily housing
Heating System Type: Ground Source Heat pump
Window-to-wall Ratio: 18%
Shape Efficiency: 70%
PV per 1000 SF (KW): 4.9
Type of solar PV: Rooftop



Energy-Plus Primary School, 2011

Location: Hoben Neuendorf, Germany
Architect: IBUS Architects + engineers
Size: 79,800 SF (7,414m²)
Stories: 2 Climate Zone: 5
Building Type: Primary School
Heating System Type: Wood Pellets
Window to Wall Ratio:61%
Shape Efficiency: 47%
PV per 1000 SF (KW): 0.7
Type Of Solar PV: Rooftop

Chapter 7

In today’s changing world, architects and engineers are addressing issues of sustainability with visionary solutions when designing buildings, homes, and urban development. There is an unrivalled collection of the most innovative architecture projects that combine creativity, scientific knowledge, technical innovation, social engagement, and a strong sense of responsibility to address environmental challenges. Those projects reference for sustainable architecture and visionary urban development.

7. Architecture of Change

Intellectual and aesthetic reflection in addressing nature and the environment in facing climate change, is inherent in all the pieces of work and positions presented here. It rapidly becomes clear that it has long been impossible for a single profession to deal with creating accomplished architecture in all its complexity, diversity and multifunctionality. Architects see themselves facing new challenges and responsibilities today that go well beyond their discipline's horizon of experience. If these challenges are not met, an integrative approach must be taken to break down the boundaries between architecture and other spheres of knowledge. The key to acquiring new insights is being able to see and think out of the box.

Some projects in the field of sustainability will be presented in a distinctive way because of their exemplary and effective role in preserving the environment by confronting climate challenges, which prompted architects to adopt a unified approach in facing the challenges of climate change by exploiting and benefiting from energy sources and integrating them into their architectural designs until they become an integral part of modern architecture as a starting point in the history of future architecture of change. Now is also the time to give credit to the many architects from a variety of professional backgrounds who have had a significant impact on modern architecture, serving our environment and preserving it from climate change, from design to construction. The quality of architecture has been greatly improved by them significant contributions, and we are especially grateful to Mario Cucinella Youmeheshe, Steven Holl, Sauerbruch Huton, Rafael Vinoly Paul Morgan Werner Sobek and others, in addition, our sincere thanks go to Mathew Peterson, CEO and President of Global Green. Leon van Schaik, Professor of innovation at the RMIT University in Australia and to the architect Ken Yeang and William McDonough, distinguished because of their exemplary role in the sphere of ecological design, for be being ready to grace Architecture of Change with their valuable and critical essays.

The distinction lies due to their exemplary role of those architects in the field of the environmental design, for giving architecture a special character that directly contributes to positive change in facing climate changes. This thesis does not drive only on their practical architectural and research projects and sound theoretical writing, but also to a great extent on the artistic contributions framing the thesis, which act to some extent here as wilful mediators at the interface between science, technology, culture, and nature.

All these contributions come together in their inspiring bandwidth to create a new picture of sustainable thinking and action that takes our built environment as an example of how to make a problem into concrete possibility. Opening up a representative insight into the current state of development in this field. Here it quickly becomes clear that within a generation, sustainable architecture has succeeded in moving away from its decades of being an outsider and into the mainstream and is now having a lasting influence on even the current artistic avant-garde. The eco-banality of its outward appearance has now given way to aesthetically demanding design concepts. Indeed, it almost seems that the ecological performance of buildings is becoming the new architectural aesthetic. So, sustainability is acquiring a new aesthetic dimension in contemporary architecture beyond its pragmatic and ethical relevance.

The projects in this chapter are brought together under three thematic headings. They are to be seen as exemplary for the development described, as environmentally aware concepts form an integral component of their outstanding architectural formal language. They are all distinguished by their flexible and holistic approach throughout the whole planning, design and construction processes. Even though the categories selected demarcate the projects from each other, the projects remain essentially open, even inviting exchanges of ideas,

Efficiency in the Everyday, this chapter looks at realised and unrealised projects that can be categorised by their sustainable intervention into everyday urban and rural life. All these contributions come together in their inspiring bandwidth to create a new picture of sustainable thinking and action that takes our built environment as an example of how to make a problem into a concrete possibility, opening up a representative insight into the current state of development in this field.

Efficiency in everyday, looks at realised projects that can be categorised by their sustainable intervention into everyday urban and rural life. Family house in Germany, Australia and England by Wener Sobek, Paul Morgan or Youmeheshe are considered along-side schools by Gruntuch Ernst, SMC Alsop or Ingenhoven Architekten, but so is experimental work by practices like Ecosistem Urbano and the Urban-Think Tank, who address the infrastructure of problem urban areas.

The Aesthetics of Performance illustrates the creative richness of contemporary architecture whose appearance is shaped by ideas on ecological performance. The range extends from straw buildings in Austria to hand-made clay structures in Bangladesh an brick buildings at the foot of the Himalayas, and then on the very modern research institutions and sky-scrapers in the U/SA, Australia Germany and China. Younger architects like Anna Herringer and Eike Roswag or KOL/MACfeature alongside internationally successful architecture practices such as that of the Pritzker Prize winner Thom Mayne of Morphosis in Los Angeles or Steven Holl in New York. Outstanding buildings by Sauerbruch Hutton, Rafael Vinoly, Mario Cucinella and many others can be found.

Didactics of engagement, discusses the work of whole variety of organisations, institutions and individual architects who have made an exemplary commitment to improving the environment we live in through their world-wide engagement in architecture and urban development. The spheres documented here range from Open-Source Internet platforms to community projects in developing countries, experimental approaches to flood protection and alternative solar power stations. Projects by architecture for Humanity, engineers without borders, Auburn University's Rural Studio and MIT's SENSable City Laboratory appear alongside those by Miralles Tagliabue, Diebedo Francis Kere and Schlaich Bergermann solar, to name but some.

The Kaleidoscopic spectrum of motivations lying behind the work presented in architecture of change presents an image of the wealth of creative ideas for developing spatial possibilities in the sustainability sphere an humanity in the built environment. When choosing projects from Africa, Australia, Asia, Europe and America, the aim was to make the wide-ranging scope of the activities clear and to show particularly successful examples.

7.1 Projects

youmeheshe – Architects – London UK

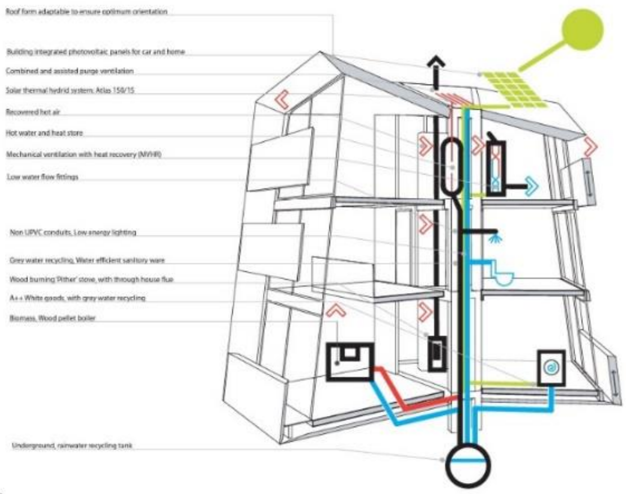
the OKO House aims to provide an innovative design that makes a carbon neutral, environmentally responsible prefabricated house available to the mass market. The prefabricated form is more about convenience and freedom; with available technology, sustainable bespoke architectural solutions are here offered at the price of mass production or mass customisation. The design of the house strives towards a constitutionally organic building. Each house touches the ground lightly, physically respecting its relationship with the earth, a central core, constructed using engineered timber, forms a structural spine: a timber frame that extends from pile foundation wings to span out over landscape.

This project explores what can be achieved within a small house; the layout is clean and rational but can be varied to suit individual living requirements. The interior can be altered, as families grow larger or smaller, with floors being added to create new bedrooms and removed to create double height living rooms or even a roof garden.

The central core is a conduit for the services allowing the side wings to be adapted to varying requirements. The core also forms storage, a chimney and, at its base, a biomass fireplace: the heart of the home. The design creates a new profile thanks o the logic of off-site construction and the volumetric configuration of spaces that allow natural ventilation, maximisation of daylight and the opportunity of reconfiguration. The design is based on prefabricated or modular components, enabling fabrication of key elements to be carried out in a controlled environment; physically and socially. The result is a house shaped by consistent quality in material, detail, and assembly.

The timber structure is produced using off-cuts from the production of soft wood plank doweled together to form larger timbe panels, solid wood construction. Although the house forms may look complex, the individual timber component shapes are nested within standard-sized timber boards with the aim of minimising waste. Complex abutments between panels can be created using a robotically controlled six-axis cutting machine, enabling the form to move away from the typical perpendicular building products. This construction strategy aims towards a synthesis between CAD and CAM.

Of all building materials, timber consumes the least energy across its lifecycle; wood structures are carbon negative. A combination of a super-insulated structure, a heat exchanger, and the orientation of the building means that all heating energy required can be obtained from passive solar gain through the large triple-glazed façade and the mobilisation of ground source heat. Thanks to passive heating, the house receives constantly filtered fresh air, creating a clean and healthy internal environment. Water collected from the roof is piped to a storage unit located within the cladding zone, adding further thermal mass. Grey water can be stored above the toilet area allowing a gravity fall system to supply the toilets.



OKO House Private Residence Byron Park, London, UK 2006

Werner Sobek – Architects – Stuttgart, Germany

Werner Sobek advanced the design concept, originally developed for his own house, the famous R128, for the private residence, south of Stuttgart: a maximum of transparency and a minimum of structure, full recyclability, extremely high user-comfort through integrated building automation and very flexible ground plans, and-last but not least-zero emissions thanks to intelligent climate engineering and highly efficient building materials. In addition, particular attention was paid to the integration of the building into the surrounding landscape, allowing for magnificent views over the town and the valley lying below. Seen from afar, the house blends harmoniously into nature.

The H 16 house consists of two contrasting cubes responding to the particular situation on an inclined plot. The transparent, all-glass cube features an open living space with a flexible ground plan and the greatest possible transparency. The black cube accommodates the prvate rooms, thus ensuring intimacy and quiet spaces for retreat. A natural stone wall provides the slope with an enclosed space and frees up space for the cubes. The ensemble is augmented by a light-coloured cube, which is visually connected to the residential building by a steel terrace. This cube houses the garage and building services. All three cubes have a supporting structure of steel that can be built up (and dismantled) within a couple of days. The steel structure is fully recyclable, as are all other materials in the house.

The transparent cube sits on top of the black cube, protruding on one side by more than six metres. It has highly insulating tiple glazing, which not only facilitates a pleasant room climate, but also allows full transparency and beautiful panoramic views of the surrounding landscape. The large glass panes can be opened on three sides as sliding door. The glass has a special sun protection coating. Additional protection is offered by textile glare shiels that can be moved up and down at the push of a button. The black cube is constructed from prefabricated architectural concrete sections. The surface of these concrete sections was finished by a stonemason to give it an amorphous character and great tactile quality. Ceiling-high (but very narrow) windows provide generous lighting and exciting views-without disturbing the very private character of these rooms. The two cubes are connected by fanfold flight of stairs made of stainless steel. The stairs are flanked by a red cabinet that links the two cubes to each other equally. The cabinet covers the full height of the black cube and goes up to parapet height in the transparent cube.

A specially adapted climate concept allows for emission-free heating and cooling. The utilisation of ground heat (geothermal heating), in connection with a heat-pump system, mechanical prime ventilation and a photovoltaic system ensures that the edifice can function without fossil fuels altogether: in energy terms, the building is entirely self-sufficient. Thus, it is fully sustainable, not only with regard to its building materials and its structure, but also to its energy system.

Temperature is easily regulated at the push of a button via a touch screen or by remote control: the same applies to turning lighting on and off, the opening and closing of doors and windows, etc. the automation of the building makes an important contribution to the very high level of comfort achieved through-out the house.

The H16 house is a tribute and, at the same time, an equal, to outstanding icons of modern architecture. The building combines sustainability (zero emissions and full recyclability), state-of-the-art design and first-class building technologies, thus making it an achievement from an architectural, technical, and aesthetic point of view.

H16 Private Residence Stuttgart, Germany 2006

The open living space in a highly insulated triple-glazed cube. Large glass panes can be opened on three sides as sliding doors. View of the connecting staircase and the town and valley lying bellow. South elevation. despite its cubic forms, the house seen from afar blends harmoniously into the surrounding nature. North-West elevation. A natural stone wall provides the slope with an enclosed space and frees up space for the cubes.

Mario Cucinella – Architects – Bologna, Italy

The Sino-Italian Ecology and energy Building (SIEEB) is a faculty building located on the Tsinghua University Campus in Beijing. It houses the Sino-Italian training and research centre for environmental protection and energy conservation. The building design aims to find a balance between energy efficiency targets, minimum CO2 emissions, a functional layout, and the concept of a contemporary building. It's the result of corporation between the Ministry for Environment and Territory pf the Republic of Italy and the Ministry of Science and Technology of the people's Republic of China. It is a platform for the development of bilateral long-term corporation between the two countries in the fields of energy and the environment and is a showcase for the potential for reducing CO2 emissions in the construction sector in China.

The building is closed and well-insulated on the north side, that faces the cold winter winds, and is more transparent and open towards the south side. On the east and west sides, light and direct sun are controlled by a double skin façade that filters solar gain and optimises the penetration of daylight into the office spaces, gardens and terraces are distinctive elements of the project. Cantilevered structural elements extend to the south, giving shade to the terraces.

The shape of the SIEEB building grew from an analysis of the site and of the climatic conditions of the city of Beijing. This shape evolved from a series of tests and simulations on solar radiation and overshadowing; its expected energy performances were a major influential factor. The main starting points for the design team were a symmetrical U-shaped courtyard building that steps downwards towards the south in order to maximise sun penetration into the internal spaces and to bring light and air into the internal garden.

The external envelope of the building plays a key role in the environmental strategy, in that different solutions respond to different orientations. The building is conceived as a protective shell towards the north, while being open to the south towards the sun, is designed to be almost entirely opaque and highly insulated to protect the building from the strong cold winter winds. Different systems of ventilated facades are used in the internal skin, facing the garden, and in the east and west outer envelope.

The south-facing façade, shaded by the cantilevering floors and structures, are more transparent. The east and west-facing facades of the building are clad with a double skin composed of a simple curtain wall based on a pattern of transparent/opaque modules and an external silk-screen façade.

Horizontal lines at different densities lend the building an elegant appearance and, at the same time, contribute to the environmental control of the internal spaces. The inner envelope, facing the internal courtyard, has a double skin composed of a simple curtain-wall system, based on the same modularity as the outer facades, and also has an external layer of glass louvers.

The louvers are composed of reflective glass panes, tilted at different angles in order to control direct solar radiation and light penetration into the office spaces. Photovoltaic panels that produce energy are integrated into the design as shading elements for the terraces.

The main aim of all the services in SIEEB is to reduce energy consumption and the create comfortable conditions. The following main technologies are applied in this project: a trigeneration system, absorption, high-efficiency condensation boilers, VAV boxes, radiant ceilings, photovoltaic panels and a building management system.

The combination of this equipment and these technological systems with the shape, orientation, materials and high-performance facades of the building allows a significant reduction of energy consumption and therefore of CO2 emissions.

SIEEB Research Centre Beijing, China 2006

Green space, gardens and terraces are distinctive elements of the research centre.
The building is closed and well insulated on the northern side, that faces the cold winter winds, and it is more open towards the south. Photovoltaic panels are integrated into the design of the cantilevered shading elements.

7.2 Self Sufficient City – Terrefuge Project Location New York City

This research project by Terrefuge is for the sustainable future of New York. It is conceptual master plan based on the premise that rapid growth, rising sea levels, urban heat island effect, and massive climate change will fundamentally alter the city. New York City is envisioned as existing in a fully autonomous and self-sufficient state without any inputs or outputs from its borders. Key areas of investigation include waste, water, food, mobility, energy, and habitat. The experiment investigates precisely how far the city can reasonably. go in taking care of these needs within its political borders. The self-sufficient city concept is predicated on testing the limits of New york’s physical capacity to take political responsibility for its own respiratory requirements within 100 years.

Location: the entire city of New York on the East Coast of the United States. Historical home to waves of immigration, this place was chosen by Terrefuge for its history of social and architectural transformation.

Concept: this project is about thinking on a colossal scale; urban infrastructure and urban resources will forever massively change to benefit the life of the planet. The project seeks to balance boundaries-the borders of New York City that are largely arbitrary from an environmental point of view but decisive from a political one. It is, in effect, a plan for testing the limits of the city's capacity to become self-sufficient in a range of areas that are vital to its survival and to its relationship to the sustainability of the planet as a whole. To do this, the research applies the economic model of import substitution, not simply to the production of goods and services but to the environmental performance of the city more generally conceived.

Realisation: New York City can lead the way by reducing its footprint on its own geography. Key measures include harvesting energy from the sun and wind, greening the city to cool it down, collecting rainwater, bio-remidiating wastes for inhabitation, growing large amounts of food, softening vehicules and taking back streets for pedestrians. New York should profoundly consider the following agendas: technologically advanced vehicles, re-imagining work on the basis of the continuous replacement of imports, remaking neighbourhoods to provide all of the needs of daily life within walking distance of home, abandoning zoning by use in favour of allowing multi-use areas, recycling old buildings into new ones, and thinking about every single aspect of planning in design with the goal of maximising independence. Terrefuge proposes a transformation of the city via a radical strategy: the reversal of figure and ground, of public and private property. Beginning with citywide greenfill, the immediate transfer of half the aggregate of street space from the vehicular to the pedestrian and public realm. Later, the streets become building sites and, as new, highly autonomous, buildings grow in intersections and wind their way down streets and avenues and through vacant lots, the old, deteriorated fabric will fade away to be replaced both by an abundance of productive green space and by a new labyrinth of irregular blocks, a paradise for people on foot. Fast movement will be accomplished underground in a superbly modernised subway and along the rivers and new cross-island channels. The city streets extended in their length but reduced in their area will support a marvellous technology we know to be just over the horizon, some fabulous and slow conveyance summoned with a whistle or collapsed into a pocket.

Energy concept: one of terrefuge's thought experiments is to reduce global energy consumption by reusing waste materials. A landfill such as fresh kills on New York's Staten Island is an easy mine for a future city. The city is disposing of 36,200 tonnes of waste per day. Most of this discarded material ended up in Fresh kills landfill before it closed. The self-sufficient city plan supposes an extended New York reconstituted from its own landfill material. Terrefuge's concept remakes the city by using the trash at Fresh Kills. With the method, seven entirely new Manhattan is lands can be remade at full scale. Automated, robotic three-dimensional printers are modified to process trash and complete this task within decades. These robots are based on existing off-the-self techniques commonly found in industrial waste compaction devices. Instead of machines that crush objects into cubes, these devices have jaws that make simple puzzle blocks for assembly. Different materials serve specified purposes: plastic for fenestration, organic compounds for temporary scaffolds, metal for primary structures, etc. eventually, the future city makes no distinction between waste and supply. Another massive energy concept for this city revolves around the sun. Terrefuge estimated that an area the size of queens covered with photovoltaics at 15 per cent efficiency will be enough to power the city per year. The cost is roughly four times that of current non-renewable power technologies and sources. Terrefuge uses these data to produce many needed iterations of New York City as an independent energy island. The idea is to later integrate different strategies to make clean renewable energy affordable, infinite, and realisable within 50 years.

GREEN DESERT MINE CHRISTOPHE DM BARLIER ARCHITECT

Assignment: Faced with the overexploitation of inner and exterior regions of megacities, there are two forms of desertification today: the destruction of fertile land and the subsequent migration of populations suffering from it. More than two billion people live in arid regions of the globe. In that light, the project tries to offer and implement new sustainable solutions to global patterns by stimulating new intellectual and economic movements within their regional populations while protecting their environments.

Location: this project is envisioned for the Eastern Sahara in Africa but can be easily applied to dry and hot areas around the globe from Southern California to the Middle East.

Realisation: some 1400 citizens would be concentrated around the tower's superstructures. By stacking and elevating the city's functions and properties above ground, the footprint is limited to 1000 square meters, thus freeing the surrounding area to function as a garden. Sheltered by a translucent double membrane capable of collecting solar energy and transmitting it as thermal energy to the chimney's turbines, the garden also functions as a mineral and biological filter system for the city's black water. Evaporated water is collected from the underside of the membrane and recycled. A drip irrigation system brings more water from nearby hills so that a rich and diverse biosphere can be encouraged along side crops grown for food.

Concept: The Green Desert Mine envisions the transformation of hostile desert areas into fertile lands, rich with biodiversity and adapted to modern lifestyles, by fighting the green house effect with similar weapons. It is a design for a self-sufficient desert city clustered around the bases of huge thermal chimneys that are capable of recycling heat.

Energy concept: after all, this grand architectural vision aims at obtaining an autonomous system in the form of a green mine where the symbolic riches unearthed are biodiversity. The updraft power plants described here are currently being developed by Schlaich Bergermann Solar. The first attempts to build an updraft power plant in Spain were undertaken in 1982. The difficulty of this construction lies in its huge size: the ideal chimney be 1000 to 2000 meters high.

7.3 Green Building and Beauty

Beauty has great importance in building including design. This holds true in green building design and, in some ways, may be even more important. As green building design professionals, we may have to hold ourselves to a high standard to demonstrate that we will not sacrifice beauty as we strive for greener buildings.

Why must buildings be beautiful? Beauty brings calm. Beauty bring pride. Beauty brings a sense of order. Beauty can facilitate our connection with nature. Beauty speaks to the great possibilities of finding harmony within and between ourselves and with the world. We leave any further defence of beauty to the poets. We proceed with the assumption that beauty is important.

Beauty is also often in the eye of the beholder. In reflecting on old and new views of beauty, we might add another criterion to the mix, the beauty of building performance. Perhaps a building that uses little energy is beautiful. A building that does not have ice dams hanging off its roof in winter is beautiful. All of these are characteristics of high-importance green buildings. Beauty for buildings should be more than skin deep.

Green design brings with it new components, such as solar panels, that need to be aesthetically integrated into buildings. For many of us, these components are a thing of beauty, but this may not be the case for all. A design professional, we need to ensure that these components are integrated in an aesthetically balanced fashion.

Green design will likely change the way buildings look. We have suggested a variety of building shape simplifications that reduce energy and material use. These simplifications, to some, might feel constraining. However, they could also direct our creativity to a new green aesthetic, new forms, and new shapes. We seek to add form to function, rather than function to form. Rather tan seeing this as a constraint, we suggest that this may be a glorious opportunity for creativity, as we engage building design on a foundation of high-performance using the vast tools of beauty, such as colour, patterns, texture, balance, proportion, and shape.

Green Building and Nature

In considering building design, it is informative to return to our initial discussions of the natural forces from which buildings provide shelter, sun; air (wind, air leaking, drafts); water (rain, surface water, subsurface water, and humidity); animal life (insects, rodents, birds, and others); temperature extremes; and contaminants (dirt, dust, mud, and airborne pollutants). It is vital to recognize these forces, to respect them, to Honor them. The site and building design can work to not only enhance the layers of shelter, and so improve protection from these elements, but also to offer ways in which building occupants can choose contact with the natural world.

Rather than promoting artificial contact with nature through building weakness, such as the large windows through which people simply look outdoors, the design professional can seek deeper ways in which to promote these connections on the site with all the tools of landscaping, vegetation, water, views, paths, fences, outdoor furniture, structures such as gazebos and pergolas, and even unusual features like mazes and three-houses. Perhaps the site can emphasize the sun with a sundial or water with a pool. Even urban buildings offer endless possibilities for meaningful, if modest, connections to nature.

We speculate that some aspects of building design have attempted to meet people’s need to connect with nature indoors. Vaulted spaces may give us a sense that we are outdoors under an open sky, unconstrained by a ceiling. Large rooms likewise offer the spaciousness to simulate the outdoors. Windows and glazed doors intentionally give us views to the outdoors and natural light from the outdoors. However, when these characteristics are taken to extremes, we suggest that they can result in artificial connections with nature, which can ultimately hurt the natural world with which we seek to connect, by polluting it and depleting it through overuse of energy and materials.

Nature presents its vastness as a paradox for people. People need protection from the forces of nature, but people as deeply also need a connection to nature, even for the hardened urbanites among us. Buildings can support meeting both needs, to protect and to connect, but, historically, our hole-ridden, moister-laden, oversized, overlift, overglazed, and energy intensive buildings have provided neither adequate protection from nature nor adequate connection to nature. We are beginning to do better.

Greener buildings offer the promise of greater protection from temperature extremes and the other forces of nature, with less pollution, greater comfort, and a greater connection to the beauty of nature.

Conclusion

A designer, we should look into ways of configuring built forms, the operational systems for our built environment and our businesses as low-energy systems. In addressing these systems, we need to look into ways of improving the internal comfort conditions of our buildings. There are essentially five ways of doing this: Passive Mode, Mixed Mode, Full Mode, Productive Mode and Composite Mode, the latter being a composite of all the preceding modes.

The practice of sustainability design requires that we look first at passive Mode (or bioclimatic) design strategies, then we can move on to mixed mode, Full Mode, Productive Mode and Composite Mode, all the while adopting progressive strategies to improve comfort conditions relative to external conditions.

Meeting contemporary expectations for office environment comfort conditions cannot generally be achieved by Passive Mode or by Mixed Mode alone. The internal sources of energy, as in Full Mode. Full mode uses electro-mechanical systems often powered by external energy sources whether from fossil-fuel derived sources or from local ambient sources such as wind or solar power.

Passive Mode means designing for improved internal comfort conditions over external conditions without the use of any electro-mechanical systems. Examples of Passive Mode strategies include the adoption of suitable building orientation and configuration in relation to the local climate as well as the selection of appropriate building materials. When considering the design of the façade issues of solid-to-glazed area ratios, thermal insulation values, the incorporation of natural ventilation and the use of vegetation are also important.

Building design strategy must start with Passive mode or bioclimatic design, as this can significantly influence the configuration of the built form and its enclosure systems. Passive Mode requires an understanding of the climatic conditions of the locality; the designer should not merely synchronise the building design with the local meteorological conditions clearly dictates that once the building configuration, orientation and enclosure are considered, the further refinement of a design should lead to the adoption of choices that will enhance its energy efficiency.

If, as an alternative, a design solution is developed that has not previously optimised the Passive Mode options, then these non-energy efficient design decisions will need to be corrected by supplementary Full Mode systems. Such a remedy would make nonsense of low-energy design.

Furthermore, if the design optimises a building’s Passive Modes, it remains at an improved level of comfort during any electrical power failure. If the Passive Modes have not been optimised, then whenever there is no electricity or external energy source the building may be become intolerable to occupy.

Mixed Mode buildings use some electro-mechanical systems such as ceiling fans, double facades, flue atriums and evaporative cooling.

Full Mode relies entirely on the use of electro-mechanical systems to create suitable internal comfort conditions. This is the option chosen for most conventional buildings. If clients and users insist on having consistent comfort conditions throughout the year, the result will inevitably lead to Full Mode design.

It must be clear now that low-energy design is essentially a user-driven condition and a lifestyle issue. We must appreciate that Passive Mode and Mixed Mode design can never compete with the comfort levels of the high-energy, Full Mode conditions. Productive Mode is where a building generates its own energy. Common examples of this today can be seen in the generation of electricity through the use of Photovoltaic panels that are powered by solar power and wind turbines that harness wind energy. Ecosystems use solar energy that is transformed into chemical energy by the photosynthesis of green plants, which in turn drives the ecological cycle. If eco-design is to be Eco-mimetic, we should seek to do the same, however we will need to do so on a much larger scale.

The inclusion of systems that create Productive Modes inevitably leads to sophisticated technological systems that in turn increase the use of material resources, the inorganic content of the built form, the embodied energy content, and the attendant impact on the environment.

Composite Mode is a combination of all the above modes in proportions that vary over the seasons of the year.

Eco-design also requires the designer to use materials and assemblies that facilitate reuse, recycling, and their eventual reintegration with ecological systems. Here again, we need to be eco-mimetic in our use of materials in the built environment: in ecosystems, all living organisms feed on continual flows of matter and energy from their environment to stay alive, and all living organisms continually produce ‘waste’.

However, ecosystems do not actually generate waste since one species ‘waste is really another species’ food. Thus, matter cycles continually through the web of life. To be truly eco-mimetic, the materials we produce should also take their place within the closed loop where waste becomes food.

Currently we regard everything produced by humans as eventual rubbish or waste material that is either burned or ends up in landfill sites.

The new question for designers, manufactures and businesses is: how can we use this waste materials? If our materials are readily biodegradable, they can return into the environment through decomposition. If we want to be eco-mimetic, we should think, at the very early design stages, about how a building, its components and its outputs can be reused and recycled.

These design considerations will determine the materials to be used, the ways in which the building fabric is to be assembled, how the building can be adapted over time and how the materials can be reused after the building has reached the limits of its useful life.

If we consider the last point, reuse, in a little more detail, we come to an increasingly important conclusion.

To facilitate the reuse of. Let us say, a structural component, the connection between the components should be a mechanical, bolted rather than welded so that the joint can be released easily. If, in addition to being easily demountable, the components where modular, then the structure could be easily demounted and reassembled elsewhere. This leads to the concept of design for disassembly (DfD), which has its roots in sustainable design.

Another major design issue is the systemic integration of our built forms, operational systems and internal processes with the natural ecosystems that surround us. Such integration is crucial because without it these systems will remain disparate artificial items that could be potential pollutants. Unfortunately, many of today's buildings only achieve eventual integration through biodegradation that requires a long-term process of natural decomposition.

While manufacturer and design for recycling and reuse relieves the problem of deposition of waste, we should integrate both organic waste (sewage, rainwater runoff, wastewater, food waste, etc.) and inorganic waste.

There is a very appropriate analogy between eco-design and surgical prosthetics. Eco-design is essentially design that integrates human-made systems both mechanically and organically with the natural host system-the eco-system.

A surgical prosthetic device also has to integrate with its organic host being-the human body. Failure to integrate will result in dislocation in both cases.

These are the exemplars of what our buildings and our businesses should achieve: the total physical, systemic, and temporal integration of our human made, built environment with our organic host in a benign and positive way.

here are, of course, a large number of theoretical and technical problems to be solved before we have a truly ecological built environment, however, we should draw encouragement from the fact that our intellect has allowed us to create prosthetic organs that can integrate with the human body.

The next challenge will be to integrate our buildings, our cities and all human activities with the natural ecosystems that surround us.

This thesis provides an in-depth understanding of sustainable development in the construction sector and provided information on concepts, issues, and implementation methods to achieve sustainable construction.

The sustainable solutions for building construction can vary significantly as some solution stage and vice versa.

For example, a specific insulation material can perform well during the operation stage, but the embodied energy of making the insulation can be very high. In this situation, the engineers should be able to justify their decision-making considering the life cycle assessment of the building. The primary topics discussed in this thesis can be outlined as follows:

Definitions of sustainability, sustainable development, sustainable construction and related topics and challenges in implementing sustainability practices.

The international and national policy developments to define a targeted sustainable development with the key indicators of those policies.

The definitions of climate change terms, global climate observations and climate projection methods using various emission scenarios. The coping methods to climate change, such as mitigation and adaptation, are also discussed.

Energy and carbon accounting in buildings throughout the life cycle.

The resource efficiency in buildings with how materials and water can be efficiently used for building construction and in operation stages.

The sustainable solid waste management in buildings with proper waste treatment methods and waste to resource management techniques.

Sustainable building design opportunities and strategies for achieving green building design, low-energy design, and Zero-energy design.

Resilience of building to changing climate with the resilient measures of thermal comfort, heat waves and durability of building materials.

These topics were covered with examples and suggestions for better understanding of different strategies that enable us to think out-of-the-box for developing new technologies. The assessment methods and critical evaluation techniques can be very useful to explore materials and processes in construction projects that are more sustainable and require less embodied energy with the reduced level of greenhouse gas emissions.

The awareness on climate change in terms of how construction practices contribute to the climate change as well as the buildings' response to climate change is discussed.

While the former issue explains how construction practices can be performed in a sustainable way to reduce the climate change contribution, the latter issue addressed how buildings should be designed and constructed to respond in a resilient manner for future climate conditions.

The understanding on the global climate change observations and future climate projection methods can be very useful to find the interaction between buildings and climate.

Sustainable resource management is very critical in the construction sector as they use a vast number of resources for construction. There are six primary themes of land, materials, water, waste, energy, and indoor environment were discussed. The efficient resource management of materials, water and waste management were discussed in detail.

The life cycle approach can be applied to many parameters including energy, emission, cost, etc., and the discussion on these topics is addressed at many places as this method is effective in quantifying the direct and indirect impacts of decision making.

The Zero-energy/Zero-emission design relies on life cycle approach and provides an insight of how each design/construction can impact the life cycle energy/emission.

Finally, the building and infrastructures are expected to be operated for a long lifespan of 50-100 years, and the resilience of buildings to changing climate should not be ignored. The major vulnerability on buildings' performance was reported as the effect on indoor thermal comfort, heat wave effects and durability of building materials.

The adaptation of buildings to climate change should be considered in design and construction stage in addition to the mitigation technologies, which are addressed through sustainable development methods.

The spectre of the many impacts of climate change and other environmental threats calls for a new architecture, a green architecture. energy use relating to buildings has been identified both as a major cause of greenhouse gas emissions and as a major opportunity to reduce these emissions. We in the design and construction field face a choice, either to bear the responsibility for climate change impacts from buildings or to lead the change that is necessary to mitigate the impacts of buildings on climate change.

The need for green buildings is moving beyond being a fad or being optional. In coming years, it will likely become as essential as fire safety and other forms of life in buildings. And so there is an urgent need to move green buildings beyond demonstration, beyond the boutique, beyond serving as a status symbol and to, instead, draw the enterprise of green buildings within the very fabric of architecture, construction, and building ownership.

Its possible that the beginning of the green building movement in the United States marks the end of the frontier movement, where every prairie and every hill called to be explored and settled, and viewed for what it could be turned into rather than for what it simply was. The end of this seemingly open abundance may itself feel hard and constraining. But as the unique human spirit is so able and drawn to do, perhaps this end and this challenge can be turned into a glorious beginning. Instead of being to mirage of an endless but actually limited frontier, the reality of green buildings can be truly boundless.

Im Gegenlicht, Joachim Fest wrote in his book a wonderful sentence: ‘First we build our buildings and then the buildings build us’. This is very important: we are influenced by our buildings and by the structures of our cities. Architecture is highly underestimated.

Fully Illustrated, Updated Guide to the Strategic Design of Green Buildings

In the tradition of building construction illustrated, Francis D.K ching and Lan M. Shapiro offer a fully illustrated guide to the theory and practice of sustainable design. This guide provides architects, designers, and builders in the green design professional community a framework and detailed strategies for designing substantively green buildings.

With a focus on sustainable sites, approaching and reaching net-zero energy, low and zero-water usage, minimum-impact materials and superior indoor environmental quality, this guide explains why we need to build green, as well as green building theory and advancements in the industry.

All new case studies featuring geographically diverse buildings with proven zero energy performance.

Expanded coverage of zero energy building design, as well as zero water and zero waste buildings.

Practical guidance for the schematic design of high-performance buildings, heating, and hot water system selection, building envelope details, and integrating renewable energy.

Advanced strategies, such as the concept of shape efficiency, and the optimal location for stairwells in buildings.

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