Ain Shams University
Faculty of Engineering

Environmental Solutions as Main Approach to Sustainable Neighborhood

Applied on New Settlements

A Thesis submitted in the Partial Fulfillment of the Requirement for the Degree of Master of Science in Architecture

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Disclaimer

This dissertation is submitted to Ain Shams University for the degree of master of science in Architecture. The work included in this thesis was carried out by the author in the Year 2014.

The researcher confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

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Date: / /2014

Acknowledgment

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Dedication

To my supportive Family

Abstract:

Societies faced serious environmental problems locally, regionally, nationally and globally, this is due to the wasteful consumption of the world's resources. All of these problems are already having negative impacts on human health, on the economy and will affect the quality of life today as well as the next generations. Moreover, cities are the focal points and drivers of societal development in all countries. They are responsible for lot of significant environmental challenges, as they are the largest consumers of natural resources and the biggest sources of pollution and greenhouse gas emissions on the planet. Thus, there is a need for a big shift in designing our cities to overcome all of these problems. Starting with the neighborhood design, which it is the beginning of any change in the cities. The actions and the decisions taken on this level are deeply in need to the integration with many variables such as design principles and technological solutions. Hence, this research is mainly attempting to apply the design principles in the sustainable neighborhood.

On the other hand, the rapid urbanization in Egypt is reflected in the increases in the percentage of the total population which is not expected to slow down. To meet these demands for housing, hundreds of integrated residential projects are being constructed all over Cairo‘s desert. As, the increasing demand on the housing units occurring in Cairo can only be met through horizontal expansion, which provides new cities for the next generations in order to accommodate with the population growth. But actually, with this expansion no regard was given towards the environmental impacts in general and the energy efficiency particularly. Hence, the research discusses the issue of planning future sustainable neighborhood, which fulfil the energy efficiency. It also evaluates the design principles that turn the residential neighborhoods to become self-sustain in order to achieve the concept of the sustainable development strategy. The design principles have been extracted through various literature sources which focusing on the design principles of energy efficiency, besides the practical solutions which have been extracted from the analyzing the different examples of eco-districts. Those principles are then used to evaluate a selected case study, which is one of the best integrated residential projects in Cairo called “AL Rehab City”. The results showed that the selected case study does not meet most of the sustainable design principles from the environmental side although it is socially and economically succeeded. This underlines the necessity to develop the design principles and update the current urban planning regulations to achieve energy efficiency in every new residential project.

Summary:

In the last decades, the global changes in the environment have had important impacts on urban areas as well as have a direct close link with the over population of the cities. Simultaneously, decreasing carbon footprint and adapting to climate change are becoming the start of any sustainable development. Thus, there is a need for sustainable neighborhoods which fulfil the future energy efficiency requirements, which they are urban areas depend mainly on their design in applying energy conservation techniques and powered by renewable energy techniques. Those sustainable neighborhoods should also be ecologically designed to enhance the health and quality of life of their inhabitants. As, in the new millennium the important goals are to make all the existing and new urban areas more self-sufficient, sustainable and enjoyable places to live. This goal needs to be taken into consideration some different measures, such as the architecture, urban planning, wastewater disposal, mobility system, as well as energy production and consumption. All of these measures need to be interlocked with one another, in order to reach the overall concept of sustainable development which aiming to decrease the ecological footprint of any built environment.

From another perspective, many cities today are facing the problem of running out of fossil fuels, consequently the future of those cities is becoming limited because there is no longer enough energy to run them. As already it is widely known that, the rate of the energy consumption has become increasingly scarce and more expensive. This means that there is a big need to a preparation for this eventuality to prevent the future crisis in the supplies and demand. On the national level, Egypt is like any other country all over the world, where the scarcity of energy sources represents one of the most challenging issues for its sustainable development. As, it has already faced the problem of the energy crisis and increasing the emissions of greenhouse gases, which arising from the burning of fossil fuels. On the other side, it has been reported that, the residential projects are the main consumer of energy within the built environment. Hence, the research discusses the main design principles that outline energy efficiency in the residential projects in Cairo. It also discusses and evaluates the design principles that turn the neighborhoods to become self-sustain, thus by decreasing the energy consumption as well as use more renewable energy sources. The target mainly depends on reaching the sustainable life for every Egyptian citizen, while decreasing their effect on the environment and also in line with the country's economy.

Those design principles have been extracted through different literature sources which focusing on the design principles of energy efficiency and also through analyzing different practical solutions for national and international projects. After that, the research analysis a case study to evaluate the main principles that affect the development of energy efficient configurations within the recent projects in Cairo. Furthermore, the research draws attention to current urban planning regulations and its close link with the energy efficient design principles. The results show that, there are some deficiencies points in the existing laws, as well as there are also some deficiency points that lack the enforcements of the energy codes and the green laws in the new residential projects in Cairo. In addition to that, the result also shows that there is a pressing need for improving the urban governance and more comprehensive planning, which include system solutions for the environment. Thus, the Egyptian government should presents new programs for supporting sustainable urban development with a main focus on achieving the energy efficiency. The government should also begin the trend of creating strategies for the new cities, taking into consideration that there is a big need to stimulate the development of new good examples that take the new settlements further towards sustainability and can serve as an inspiration and sources of knowledge to others.

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1.1. Introduction:

It has been reported that, more than 50% of the world's populations live now in cities, megacities and large urbanized regions. This percentage will continue to increase and it's expected to rise to 70% by 2050. Even though, cities occupied just 2% of the world surface area, 80% of the world resources are used in them. Furthermore, cities are the main responsible for the wasteful consumption of water, energy and other resources, with the lack of appropriate infrastructure and technology (IBA Hamburg, 2010 & Price et al., 1996). This percentage of the consumption and the associated emissions will increase with the ongoing urbanization. Consequently, if the current and future urban areas will be continued with the same resource consumption practices without regard to the future needs of the rapid population; serious environmental, social and economic problems will be expected to happen. Thus, numerous studies have investigated and offered different approaches to achieve sustainability in contemporary time. This mainly required a major paradigm shift, essentially reversing traditional development and changing the current philosophies and behaviors. Moreover, it is widely agreed that, many cities around the world have already developed their sustainable urban development plans for leading their urbanization process towards a desired status of urban sustainability. Those plans apply the suitable design principles to improve the quality of life of citizens, while minimizing their impact on the environment (IBA Hamburg, 2010& Shen et al., 2010).

Other approaches concentrated on providing practical solutions for the most serious present day and future problems of mankind, which represented a challenge in all areas of urban life. It can be said that, the cities of tomorrow are faced with pressing challenges resulting from high energy consumption, concentrated emissions, as well as the consequences of the climate change. Those problems mainly demand great efforts to keep the risks at an endurable scale. The question of how cities need to be reacting to these challenges is now being posted all over the world (IBA Hamburg, 2010). Thus, this means that the climate change is now no longer possible to prevent it, but it is possible to mitigate and avoid the worst consequences of it (Thomas, 2003). As it is widely agreed that, the climate change ranks as the second most important problem after poverty, food and water shortages among the global problems, while also the poverty, hunger and water shortages are often directly related to it (IBA Hamburg, 2010). So, there is a need for acting fast and effectively, with a major shift in human behavior to overcome the causing of the climate change.

On the other side, not only the climate change which needs to act fast, but also controlling the over-consumption of fossil fuels. As, it is assured that, the energy has been a key factor in the development of countries, enabling their economic growth and shaping their environments. As well as, its play a great role to run the cities and if it vanished, cities are no longer to be extended or powered. Nowadays, it has been reported that, more than 85% of global primary energy is supplied by non-renewable toxic sources, especially oil, which is entering a historical peak. On the other side, it is also has been reported that three quarters of the CO_2 emission rise is due to the consumption of depleting fossil fuel resources (IBA Hamburg, 2010). Yet, there is range of serious problems has evolved due to the increasing requirements for energy and its carbon based generation. Those problems vary from economic to environmental such as the exhausting of the resources, air pollution, as well as the global warming which lead to the flooding, extremes of weather and the melting of the glaciers (The Environmental Literacy Council, 2013). In general, energy supplies and reducing energy consumption play a key role in mitigating the climate change and reduce CO_2 emissions, thus urgent needs for decisive measures should be taken to face this problem.

These facts make it clear that, the cities claim as focal points for any change, they have a particular responsibility to get their emissions under control. As it’s worth mentioning that, cities are the largest cause of the environmental problems, although they will be directly affected by the consequences of all of the future challenges. Mainly, these challenges are closely related to the issue of what the city is going to look like in the future. In general, it can be said that; the future will be characterized by very real adjustments to avoid consequences of wasteful consumption of energy in particular and the adoption of sustainability practices generally. This target has to be broken down according to all of the individual city’s districts and neighborhoods (IBA Hamburg, 2010 & Reed et al., 2009). On the other hand, there is an urgent need for radical redirection in order to achieve this target through applying different measures on energy, urban planning concepts, transport, new energy supply concepts, architecture and construction engineering (IBA Hamburg, 2008).

On the local level, Egypt like many other developing countries is often categorized by high growth in electricity demand, high commercial and technical losses in a context of rapid growth and development. It is also categorized by the fact that, the population growth rate is faster than the rate of developing infrastructure and the services for the people, while the growth rate of productivity is lower (Schiller & Fassmann, 2010). Moreover, in the last few years, Egypt’s energy activities are one of the major sources of pollution which might represent a threat to the ecosystem, land, water and air (Georgy &Soliman, 2007). At the same time, it is widely agreed that, many citizens in Egyptian cities and communities are living under unsustainable conditions, as well as the cities are also increasingly getting overwhelmed by social, economic, ecological and cultural problems. Thus, in order to adapt to all of these present aspects, which represent both significant challenges and opportunities, the government has adopted new realistic and comprehensive strategies, in order to develop the existing cities and create new cities in the unexploited desert (Shalaby, 2000 & Goell et al., 2009).

Furthermore, those new cities in the unexploited desert will be extended during the coming years around Cairo, in order to overcome the growing demand on the housing sector. It's worth mentioning that, they are not planned to be environmentally friendly, as they have a big role in the wasteful consumption of all the natural resources and particularly energy. Thus, those new cities with all of their settlements and neighborhoods need to be well planned in order to be more environmentally and energy efficient, before allocating huge budgets for building them. These proposals have to be a model study, which apply the most appropriate sustainable design principles in all the new settlements in Egypt or even in the traditional ones. In general, the development options have to be carefully studied with regards to the criteria for sustainable development and specified according to the recent energy crises (Goell et al., 2009).

Hence, the research aims at creating a criteria system for sustainable neighborhood, particularly the Egyptian new settlements, in order to reach a healthy life for everyone in Egypt while decreasing their effects on the environment and also in line with the country's economy. So, the research mainly described a model design for urban development that will achieve energy efficiency configurations and enable all Egyptian settlements to become more sustainable.

1.2. Research Problem:

According to the negative impacts of the overpopulation, which led to serious environmental problems such as the resource consumption in general and particularly the energy crisis with its close link with climate change, the research showed how a neighborhood gradually becomes sustainable and fulfills all the future energy requirements at the same time. As it is widely agreed that, the rate of the energy consumption has become increasingly scarce and more expensive, also at the same time there is no longer enough energy to run the cities. This problem affects not only Egypt, but also the future of the all cities all over the world. Consequently, new technologies, new sustainable energy systems, as well as applying energy efficient design principles are required within a short period of time to be able to path the way out of some of the future challenges.

1.3. Research Hypothesis:

Residential projects all over the cities are the main consumer of energy within the built environment. They consume around 21% of the energy, which is accounted for 39% of all greenhouse gas (GHG) emissions, see figure (1.1) (Hoffman, 2008). Also, in Egypt; more than half of electricity consumption takes place in residential, commercial or public buildings and this consumption is growing at a rate of approximately 7%/year. Producing this electricity takes approximately 65% of domestic natural gas supply and 15% of petroleum supply. This energy demand of buildings will continue to grow at the rates which have negative impacts on the environment, as well as the country's economy (HRBC, 2010).

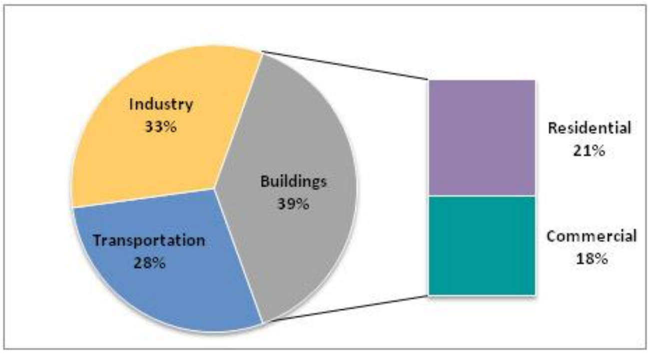


Figure (1.1): The Energy Consumption Rate
Source: (Center for Climate and Energy Solutions, 2014)

It's worth mentioning that, unfortunately a large part of the energy consumption is derived from cooling and lighting service in the buildings. Thus, intelligent construction of the new buildings, using orientation, structuring of the building envelope, control of ventilation and natural light are preferred to be designed. This may be extended to reducing the artificial cooling and heating demand to virtually zero without major additional cost, as well as minimizing the impacts on the environment (HRBC, 2010). Therefore, the study presents a method for evaluation of the fundamental role of residential buildings in achieving the concept of the energy efficiency. As, in general, if the requirements of energy consumption are decreased and programs are addressed to switch to smart energy distribution, also another line of action applied in order to use the renewable energy in a highly efficient way instead of fossil fuel resources, a full sustainable energy stratagem will be carried out in order to achieve a healthy environment friendly settlements.

1.4. Research Questions:

1. How can cities sustain reasonable growth in the future?
2. How can cities react to the challenge of the wasteful consumption of the resources in general as well as the energy crisis and the climate change particularly?
3. How can the existing and new urban areas become more self-sufficient, sustainable and enjoyable places to live?
4. Is it technically possible, to use currently available solutions in the urban neighborhoods to reduce their GHG footprint, while becoming more attractive for the residents and for the economy at the same time?
5. What do cities technically need to be energy self-sufficient, as well as can be converted to apply the full sustainable energy systems within a short period of time?
6. What are the policy changes that might be needed to promote the concept of sustainable neighborhood, which fulfilling all the energy future requirements?

1.5. Research Objective:

The research aimed at creating a criteria model for sustainable neighborhoods which fulfills future energy requirements based on the real experiences from national and foreign projects. The main focus is to analyze and assess the possibilities and the potentials for the Egyptians new settlements in applying the efficient design principles and utilized all of their resources in sustainable ways, that in order to become self-sustain. In general, the research tried to reach to an overall model based on the extracted criteria system, as well as a proposed recommendation for sustainable neighborhood in Egypt, which could be used as a benchmark for development of Egyptian settlements and communities in general.

- **General objective:**

The primary goal is to provide a checklist for Egyptian architects and planners to achieve the sustainable design approaches that facilitate fulfilling future energy requirements and compare to which extent those residential projects in Cairo are successful in meeting this checklist. On the other side, it focused on proposing a conceptual framework and inspired methodology by highlighting on the deficiency points in the current regulations which set by government. Thus, in order to study the relation of the laws with energy efficient design principles, as well as to draw out the main deficiencies that lacks the enforcements of the energy codes and the green laws in the new residential projects in Cairo.

- **Specific objectives:**

Study the effect of outdoor environment on building performance (heating/cooling loads and indoor temperature) in an urban block, that to investigate how the design principles can support the concept of energy efficiency system which is a very complex task. Thus, intelligent integration of the energy production, distribution and energy consumption all will play a virtual key role in order to reach this complex system.

1.6. Research Methodology:

This thesis identifies the design principles that address sustainability issues with the broader aim of creating a model checklist to enhance sustainability in the residential built environment. Also, it focuses specifically on the challenge of how to find innovative concepts for a safe, sustainable and economic energy supply in the future.

1.6.1. Theoretical Part:

This part was depended on the theoretical approach followed by the analytical part of the major elements affecting the design criteria. So, it reviewed the theoretical background and the existing design principles that address sustainability issues in general and energy efficiency requirements particularly, both at the neighborhood level.

Thus, there are numerous aspects that will be discussed among the literature review part. Among those aspects is the theoretical basis of what is meant by neighborhood, as well as the conceptual form of how a sustainable neighborhood may look like. In addition to that, this part also discussed the role of the neighborhoods in achieving sustainability and energy efficiency at both the city and the residential building level. At the same time, the last part of the literature review focused mainly on the design principles of the energy efficiency configurations, which help in reaching a sustainable neighborhood that fulfills all the future energy requirements. Among those principles are:

(1) Urban Scale: Which include: orientation, wind direction, solar radiation, properties of the surrounding environment, water features, block density, urban greenery, as well as exterior block properties.

(2) Architectural Scale: Which include: building envelope properties such as the wall properties, roof and ceiling, daylighting techniques, openings properties, insulation techniques, shading devices' dimensions and types and natural ventilation system.

Finally, the energy efficiency checklist will be illustrated that could be used as a base for evaluating and as a road map for assessing energy efficiency at any residential built environment or any new settlement.

1.6.2. Analytical Part:

As it is widely agreed that, the building affects its surrounding environment and conversely its indoor environment is influenced by its surroundings. Thus, the study concentrates on analyzing the effect of outdoor environment on building performance in an urban block which mainly consists of several buildings and other structures. Yet, the key concept of this part is not to evaluate theoretical principles or evidence, while finding more efficient practical solutions and analysis the drawbacks of their practical implementation. Thus, this part depends mainly on analyzing different real experiences from national and international projects. The main focus of this analysis is mainly on the physical design principles which underlying the energy efficient configurations on the urban and architectural scale as a level of action. Finally, the common practical solutions which have been extracted from the comparison could be applied at any new settlement.

1.6.3. Experimental Part:

The research mainly depends on analyzing a case study for ‘Al Rehab City’ which is one of the largest and successful communities in our country, in order to convert it to be a healthy sustainable neighborhood which fulfills all the future energy requirements. In chapter five, the discussion of the selected case study had been set against the design principles of the sustainable neighborhood, which had been extracted from the literature review and also through the common practical solutions which have been extracted from the analyzing of the different examples. The analysis had been done by using a simulation tool (Vasari), in order to make a comparison between the situations now and the proposed solutions which may be help in enhancing the design principles of energy efficiency within the project. In general, evaluating the local experience of establishing a new residential neighborhood is highly needed to get some guidance and ideas which clarify the future vision of the government in order to achieve new environmentally liveable settlements in Cairo.

The following figure (1.2) shows an abstract of methodology and research structures:

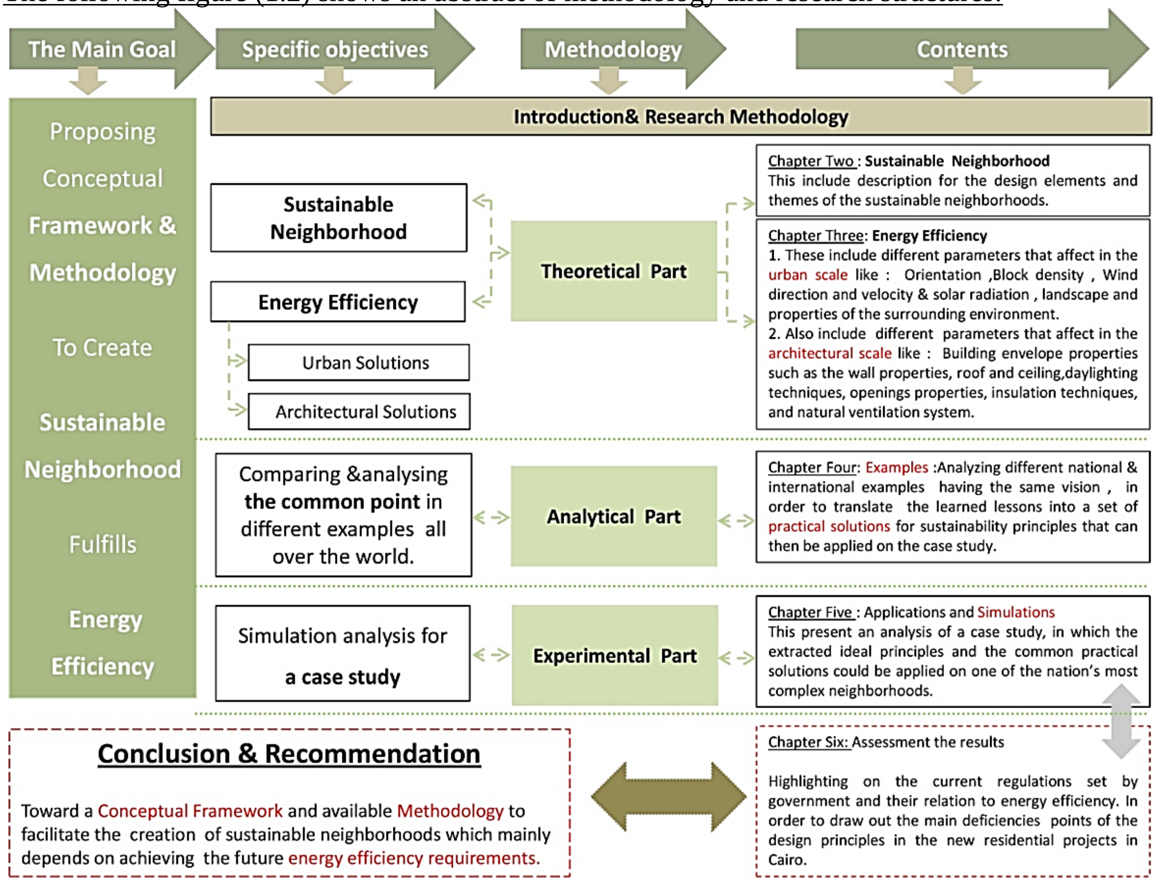


Figure (1.2): Abstract of Research Methodology & Structures
Source: Adapted by the author

1.7. Research Structure:

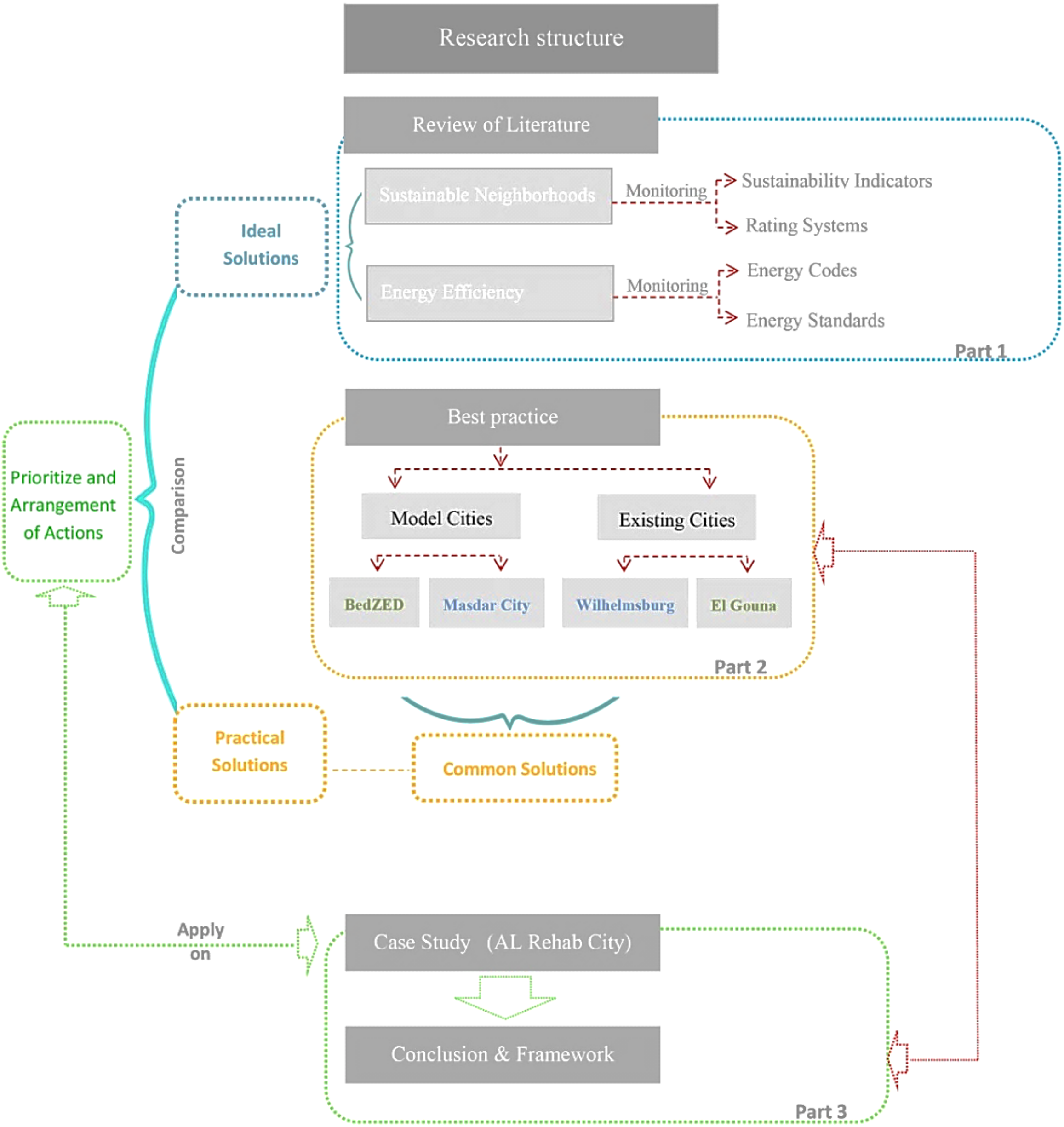


Figure (1.3): The Research Structure
Source: Adapted by the author

The First Part; (Introduction& Research Methodology):

- **Chapter 1:** The thesis started with the introduction chapter, which aimed to describe in details the research methods that the researcher has been used to achieve the research's objectives and goals.

<u>The Second Part: (Literature Review):</u> This part is divided into:

- **Chapter 2:** Described the design elements and themes of the sustainable neighborhoods.
- **Chapter 3:** In this chapter the concentration mainly would be on the energy efficiency, which is the major element in the sustainable neighborhoods, in order to provide in details the process for developing and implementing a sustainable energy plan. Also, it got out with some energy efficient design principles, which had been extracted from diverse literature sources and then concluded in a checklist in order to be used as a base for evaluation and monitoring of the residential projects' energy efficiency.

<u>The Third Part: (Examples):</u>

- **Chapter 4:** This chapter was mainly based on analyzing different experience for sustainability practice on the local level of Egypt and other several countries all over the world. The cases ranged from model cities development strategies to exiting cities development approaches. That would stimulate the mutual exchange of experience for a more sustainable future, in which the focus was given to extract the learned lessons. After that translated this experiential input into a set of practical solutions for sustainability principles, that can then be applied on the case study. Also, based on this range of experiences chapter six offers the overall conclusion, as well as the inspired framework, that then can be used as a base for the evaluation of the existing situation in the Egyptian settlements.

<u>The Fourth Part: (Application):</u>

- **Chapter 5:** This present an analysis of a case study, in which the extracted ideal principles and the common practical solutions could be applied on one of the nation's most complex neighborhoods. Throughout the analysis, the research tried to draw out the overall conclusions, which eventually lead to proposing ideas and some guidance for the residential projects targeting them to minimize their energy used, as well as achieve new environmentally liveable settlements in Cairo.

<u>The Fifth Part: (Conclusion and Recommendations):</u>

- **Chapter 6:** This chapter focused on how the governments can work better to realize the aspirations of the sustainable development framework. As a result the chapter mainly presented an inspired framework, which was based on the analysis done on the examples and the case study. This framework is applicable to highlight on the role of the government to achieve energy design principles, as well as to evaluate the close link between the existing laws with energy efficiency configurations in order to draw out the main deficiency points. It also sets out some recommendations to develop the design practices and update the current urban planning regulations to optimize the implementation of the sustainable neighborhood program which emphasizes the energy efficiency results in shorter time.

1.8. Research Focus:

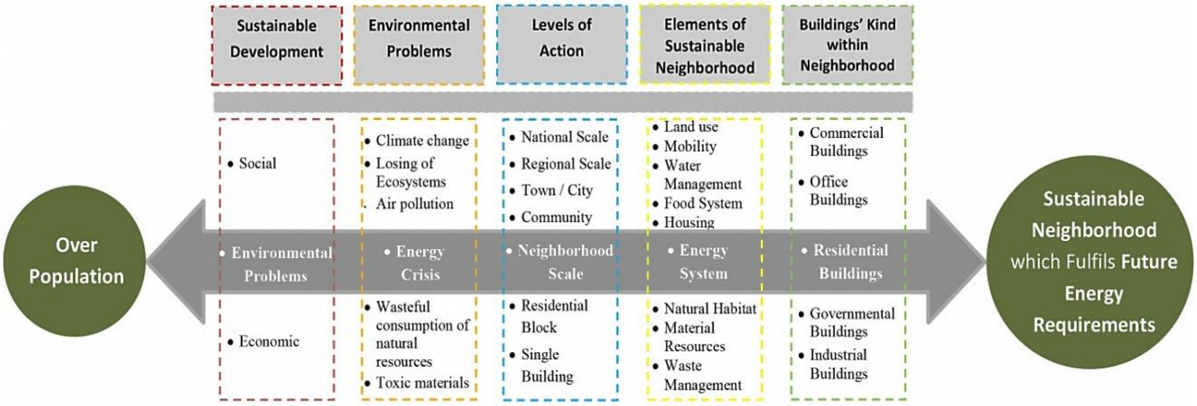


Figure (1.4): The Research Focus
Source: Adapted by the author

- Sustainable Development:

Sustainable development programs have been developed in many cities around the world for leading their urbanization process towards the desired condition of urban sustainability. This concept depends on the proper use of resources to guarantee social equity, protection of the natural environment, as well as economic diversity (Shen et al., 2010). It's worth mentioning that, if the current and future urban areas continue with the same rate of the resource consumption practices without regarding their environmental impacts, consequently serious environmental, social and economic problems are expected. In this research the focus would be only on the environmental aspect, but it does not mean that the other aspects are not also having a major effect. As, it's all about a whole system must work together to achieve the best performance of the sustainable development program.

- Environmental Problems:

It has been reported that, societies have already faced serious environmental problems which lead to numerous negative impacts on the human health. Among those problems there are the losing of valuable ecosystems and lands for satisfying the urban needs. In addition to the wasteful consumption of water, toxic materials and removal of resources from natural cycles and finally the energy crisis with its close link with climate change. It is widely agreed that, the most serious present day and future problem not only in Egypt, but for the whole region is considered to be the energy crisis (Lindström & Lundström, 2008). Hence, the research mainly focused on the ways to solve the problem of the energy crisis, which consequently has a significant effect on the global climate change problem.

- Levels of Actions:

It's worth mentioning that, there are many levels of action to solve the problem of the energy crisis in the built environment. Starting with the national level for a whole country or a region, in which certain policies and strategies should be set, as well as a better monitoring system should also be created. On the other side, it is also widely known that, there is another scale which already looking at ways to make individual buildings more sustainable, but few are elevating this discussion to the level of communities (Falk & Carley, 2012). Among this research the focus mainly would be on how to apply the sustainable design principles on the neighborhood scale. As improving sustainability at a neighborhood level contributes to more sustainable environments at a wider scale, this may be returned to the importance of the neighborhood in decreasing the gap between buildings and cities at the regional systems as a whole (Hargreaves et al., 2004).

- Elements of Sustainable Neighborhoods:

It is quite important to know that, any sustainable neighborhood depends mainly on different interlocked elements. Among those elements are: natural systems, land use systems, mobility, energy systems, water management, material resources, waste management and affordable housing (McGeough et al., 2004). The main focus of the research was on achieving the energy efficiency system, this may be returned to the reason that the energy system has a key factor in the development of countries, enabling their economic growth and shaping their environments to the needs of human society.

- Buildings' kind within neighborhoods:

As mentioned before that, the residential projects all over the cities are the main consumer of energy within the built environment. They consume around 22% of the energy, which is accounted for 39% of all greenhouse gas (GHG) emissions (Hoffman, 2008). Thus, if the energy conservation in the residential buildings decreased, that helps in carrying out sustainable stratagem and reducing greenhouse. Hence, the main focus of the research would be on the residential buildings in warm hot climates.

1.9. New Settlements:

Egypt is like many other places in the world, which is often categorized by the rapid urbanization. This can be reflected by increasing in the percentage of the total population, which consequently have negative impacts on the wasteful consumption of resources and shortage of available housing. To meet these rapid demand for housing, the Egyptian Government has pursued a desert development strategy to create new urban communities and populate the desert prevails. The main focus of this strategy has been on developing new towns and settlements, as well as providing significant incentives to encourage economic activities to locate in uninhabited areas (Goell et al., 2009). It's worth mentioning that, these new settlements lie under the responsibility of the (NUCA), which is the New Urban Community Authority in Egypt, as well as they are classified into three generations, as shown in the figure (1.5). All of those settlements are established with the aim of pulling the population out of the crowded Nile Valley and to attract part of the overpopulation in existing cities (NUCA, 2008).

In the matter of facts, the conquest of those new urban environments became no longer a slogan or a dream, but a necessity to accommodate with the population growth, as well as to adapt to the high demand for housing sector occurring in Cairo (Shalaby, 2000, Goell et al., 2009). On the other side, it's worth mentioning that, unfortunately with this expansion in designing new neighborhoods, no regard was given towards the environmental impacts in general and energy efficiency particularly. As, it becomes a fact that, many citizens in the Egyptian Communities were living under these kinds of unsustainable conditions. On the other side, it is widely agreed that, the government and the private sectors just took the direction to create the new residential neighborhoods with the aim for achieving business and financial goals. Those neighborhoods have become places for doing business with millions of vacuum housing rather than places where communities live (Goell et al., 2009).

Figure (1.5): Classification of the New Settlements in Egypt
Source: (NUCA, 2008)

Hence, as it is previously mentioned that, the expansion of the new settlements will be expected to be increased within the coming years, in order to overcome the growing demand on the housing sector. Also, as it is widely known that, those settlements have many problems which need a concrete action. Thus, there is agreement that, those settlements really need to be developed, as well as they should be well planned according to sustainable design principles, which mainly achieve the sustainable life that fulfills the energy future requirements in those settlements. This mainly should be done before allocating huge budgets for building them and damage the environment at the end. Therefore, the research focused mainly on the evaluation of a selected neighborhood within the New Cairo, which represent one of the second generation communities. The research selected the case study, in order to analyze the evolution of the experience aiming to identify the positive and negative aspects, as well as extract important outcomes.

1.10. The Aim of the Case Study:

The research mainly selected Al Rehab City as a case study in order to be a role model to many of the future new settlements in Egypt, which aim to achieve a great reduction in the environmental impacts. As it is widely agreed that, Al Rehab City is famous with its success as a role model in the social and economic aspect, while there is a little debate to know if it is succeeded from the environmental aspect or not. Thus, the research evaluated the environmental aspect, which mainly based on the design principles of sustainable neighborhood. These principles have been extracted through various literature sources with a comparison to the practical solutions from the different examples.

1.11. Literature Review:

To outline the principles of the sustainable neighborhoods, some of the literatures have been explored concerned with how to achieve the sustainability on the neighborhood level with the attempts to draw out some lessons. The literature review has been investigated in works done by some researchers such as the findings reached by Lindström & Lundström (2008), in ‘Sustainability by Sweden perspective on Urban Governance’ and also the design principles of sustainable neighborhoods which has been demonstrated by Kellett et al. (2009), in their studies on ‘Specification of Indicators and Selection Methodology for a Potential Community Demonstration, Project-Vancouver’. In addition to that, other researchers’ findings on the theoretical ground of the sustainable neighborhood in the study done by Talen & Kochinsky (2010), with title ‘Subsidized Housing in Sustainable Neighborhoods’ and the also contribution of the sustainability indicators in another study done by Shen et al. (2010), with title ‘The application of urban sustainability indicators’.

Besides, it’s also worth mentioning that, other studies and researches have been mentioned within the research to outline the principles of the energy efficient configurations at the neighborhood level. This part represent a desk research which has been explored some of those researches such as the findings reached by Allen & McKeever (1996), in his study ‘energy yardstick: using places to create more sustainable communities’, in addition to that, there is a research on the design principles of sustainable energy cities in the developing countries which has been done by UN-HABITAT & UNEP (2009), in their report with title of ‘Sustainable Urban Energy Planning- A handbook for cities and towns in developing countries’. Besides, there are other research findings on the theoretical ground of energy consumption at homes such as the one which has been done by Leona (2005), in ‘Energy Smarts: Checklist to Determine Energy Efficiency of a Home’ and also another study which contributes the design manuals for homes and it’s done by Gamble & Hall (2004), with title ‘Building a Path towards Zero Energy Homes with Energy Efficiency’. Last but not least, there is also another study done by Taiao (2008), which is focused on the design principles of the passive house and it’s well known with a title ‘Passive Solar Design Guidance’.

For the last part, this represents the evaluation of the existing situations on the local level at Egypt. There are some researchers have been mentioned within the research related to the Egyptian Context, as they discussed the sustainability aspects of the urban design for new cities such as the researches done by Bayoumi et al. (2007), in their study with a title ‘Egypt National Capacity Self-Assessment (NCSA)–National Strategy and Action Plan for Capacity Development’. Also, there are other important studies which investigate the existing Egyptian conditions such as the one done by Shalaby (2000), in ‘Compact Urban Form’, as well as the one done by Ayyad K. & Gabr M. (2012), in ‘Greening Building Codes in Egypt’. Besides it is also important for the study to review efforts done by Georgy & Soliman (2007), in their studies with title ‘Mediterranean and National Strategies for Sustainable Development, Priority Field of Action 2: Energy and Climate Change, Energy Efficiency and Renewable Energy, Egypt - National study’, as their study aimed towards a more sustainable and energy efficient built environment within Egypt and also discussed the ability of country to apply the vision of the national sustainable development strategy which mainly target to use the energy potentials in the best way. Finally, it was also important for the study to review some of the efforts done by different organizations in Egypt, such as (New and Renewable Energy Authority (NREA), the Ministry of Electricity and Energy (MOEE), the Ministry of Petroleum (MOP), as well as the New Urban Community Authority (NUCA), which is an agency under the Ministry of Housing, Utilities and Urban Development. In addition to, the efforts have done by the Housing and Building National Research Centre (HBRC) in establishing the energy codes and the Egyptian Rating System.

1.12. <u>Conclusions:</u>

The results showed that, the housing projects in Cairo, need more attention and help to respect the vision of sustainability in supplying suitable units with proper performance. As the challenges today is to overcome the rapid demand on the housing sector, while improving the living conditions in the future. This mainly represents a big and complicated task, which need great efforts to be applied. After analyzing the examples and the case study, it is clear that the traditional styles of policy-making and governance are not able to cope with those challenges. Hence, the conclusion showed that what is really needed is a more innovative development with a participatory approach, as well as a new governance style is preferred to provide better management. At the end, the research tried to draw out an inspired conceptual framework with a main aim to create sustainable neighborhoods that facilitate fulfilling energy future requirements. On the other hand, the research also evaluated the main deficiencies of the design principles in the new residential projects in Cairo by focusing mainly on the close link between the existing laws and the energy efficiency, in order to make them able to meet the future energy requirements.

2. Chapter Two: Sustainable Neighborhood

2.1. Introduction:

This chapter aimed at investigating the key issues related to the essential role that sustainable neighborhood can play as a tool for assessing progress towards sustainable development. It reviewed the literature about ' Sustainable Neighborhood ', in order to outline the principles of configuration that are necessary to achieve sustainable neighborhoods in many cities around the world. The chapter started with providing a brief explanation of the concept of sustainability and sustainable development, as well as the challenges they face. Then, it explored the concept of the 'Sustainable Neighborhood' and the methodology behind its elaboration with focus on its design principles and themes. Additionally, key issues related to developing sustainability indicators and assessment tools are then investigated, with focus on the powerful role they can play in operationalizing sustainability. The main conclusion of this chapter is to set out some of the background issues surrounding the development of the neighborhoods.

2.2. Sustainable Development Plans:

In the last decade, all of the cities across the world have started to put plans to overcome the rising of environmental concerns and problems which became on the top of the agenda in every city. They tended to explore new approaches which are depending mainly on the surrounding growth and sustainability. Those approaches are considered to be the definitions of any sustainable development. From an another perspective, cities used urban planning as a tool for facing up the unprecedented challenges facing 21st-century cities and for promoting sustainable development (Shen et al., 2010).

Other studies and researchers showed that, the concept of the sustainable development plans in many cities around the world have been developed for leading their urbanization process towards the desired status of urban sustainability. This concept has depended on the proper use of resources to guarantee equity, protection of the natural environment, minimal use of non-renewable resources and economic diversity. Also, to guarantee community self-reliance, individual well-being and satisfaction of basic human needs (Srinivas, 2005). According to that, it is quite important to define the urban sustainability as “the challenges to solve both the problems experienced within cities and the problems caused by cities, recognizing that cities themselves provide many potential solutions" (Shen et al., 2010). This urban sustainability depends mainly on two terms, which are the terms sustainability and sustainable development. Despite of the quite different meaning, these terms are often used interchangeably. Thus, it is important to understand the difference between them, also how the two concepts can be interacted (Woods, 2002).

2.2.1. Sustainability: The term of sustainability can be investigated in a study done by Meter (1999) as a term that can have different and often opposing meanings when applied to economic, social and environmental situations. Sustainable definition shows the close linkage of the three important spheres of life which are: social, economic and environmental health of the community, as shown in figure (2.1). Besides, there are other studies would also add a fourth sphere, either "cultural" or "civic". Actually, sustainability does not generally have only one definition, but it is usually referred to the concept that person's lifestyle would be more integrated in a sustainable world and can be carried out over a long term (Hoffman, 2008).

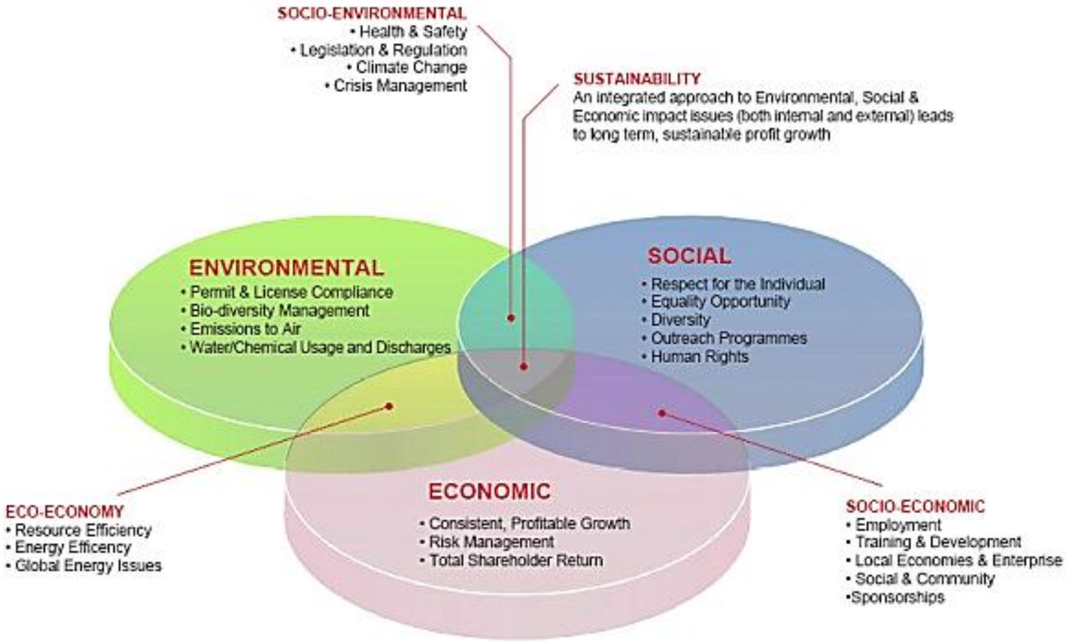


Figure (2.1): The Three Circles of Sustainability
Source: (Hoffman, 2008)

From a general point of view, there are at least two ways to imagine the correlation of the three important spheres of sustainability. In the two cases the zone of sustainability is the zone, which brings the three domains into harmony with each other. Accordingly, the sustainable space can be showed as the area where the three domains interlocked, which shown in figure (2.2) or as the overlapped area which shown in figure (2.3) (Meter, 1999).

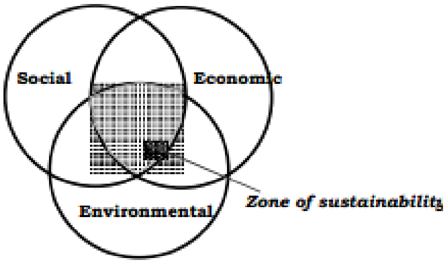


Figure (2.2): The three interlocking circles
Source: (Meter, 1999)

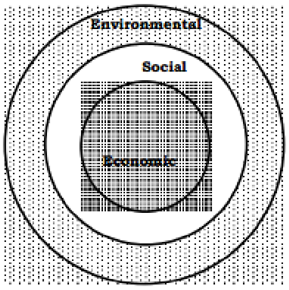


Figure (2.3): The three overlapping circles
Source: (Meter, 1999)

In general, the study done by Woods (2002) that investigates the concept of sustainable development as a contested paradigm, concluded the sustainability's aspects into three terms. First, in the term of the economically sustainable system, the study defined it as a system which is capable of producing goods and services on an on-going basis to maintain manageable levels of government and external debt. While, the environmentally sustainable system was defined as a system that preserves stable resource base and prevents the over-use of renewable resource systems. This system includes maintenance of biodiversity, atmospheric stability and other ecosystem functions not ordinarily classed as economic resources. Thus, it was recommended that laws and regulations must designate to effectively prevent pollution of the air, water, or the property of another. Finally the last aspect which is the socially sustainable system, it was defined as the system which must achieve distributional equity, adequate provision of social services including health and education, gender equity and political accountability and participation.

2.2.2. <u>Sustainable Development</u>: On the other side, sustainable development refers to processes which maintaining the development all over the time. It is a term that can be achieved by the adoption of policies and programs to solve the global problems. It's worth mentioning that, it is the main concern for the decision makers, experts and planners at local, national and global levels. However, it has been suggested that there are over 100 definitions of sustainable development currently in circulation (Srinivas, 2005). The most widely quoted definition is taken from the Bruntland Report, which defines sustainable development as: "The development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987).

From this definition, three key ideas can be concluded which are the development, the needs, as well as the future generation. During the term of the definition of the development, it should not be confused with growth. As it's worth mentioning that, the growth represents a quantitative expansion of the economic system, while the development represents a qualitative concept. In general, the development is mainly concerned with cultural, social and economic progress (Srinivas, 2005). On the other side, it was stated by Donia (2007) that, the term needs introduces the ideas of distribution of resources. This means that, the concept of the need may be defined as meeting the basic needs of all and extending to all the opportunity to satisfy their aspirations for a better life. For the third idea, which mainly introduces the idea of intra-generational equity. This can be shown by Srinivas (2005) that, any particular generation needs to protect their planet and to use wisely non-renewable resources, in order to hand it on in good order to the future generations.

Hence, to conclude; the sustainable urbanization refers to the well-balanced relationships between the social, economic and environmental agents in society in order to accomplish sustainable urban development. This in general requires that the negative effects on the quality of air, water and other natural elements should be minimized so as to sustain the ecosystem’s overall integrity. Thus, all the terms such as the “urban sustainability, sustainable city and sustainable community” refer to the desirable state, while the term “Sustainable urban development” refer to the process that leading to desirable state, in which raising the living standards and improving the well-being of people are the main target (Shen et al., 2010).

2.3. <u>Neighborhood Scale:</u>

Actually, it is quite important to mention that, that there are many levels of action to achieve the expression of the sustainable development definition. The study by Falk & Carley (2012) concluded that, there is a level in which the whole country has designed as a sustainable system. This level, mainly depends on the strategies which set on the national level for a whole country or a region. Besides, there are other levels, such as the design of the city, or the design of a single community, in addition to the design of groups of buildings on the neighborhood scale, until it ends with the design of a single building. Among all of those levels of action, the research focuses on the neighborhood scale, as it is widely proved that improving sustainability at a neighborhood level will contribute to more sustainable environments at a wider scale.

Nowadays, it is widely recognized that, the neighborhood sustainability is the critical element for the sustainability of the built environment, in which the triple bottom-line of social, economic and environmental outcomes can be usefully operationalized (Smith et al., 2006). Furthermore, other studies and researchers showed that, the reality in planning sustainable city can never be sustainable if its neighborhoods is not sustainable. Also, if not the city's neighborhoods help in contributing and saving the resources rather than consuming them (Lindström & Lundström, 2008). On the other hand, the study issued by Hargreaves et al. (2004) explained that; the neighborhood has been neglected and have less attention in spite of the fact that it is the middle bit, in which the gap between cities and buildings can be decreased, as shown in figure (2.4).

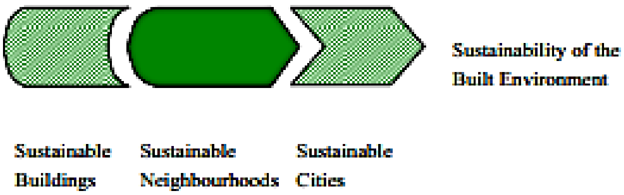


Figure (2.4): The sustainable neighborhoods as a critical link
Source: (Hargreaves et al., 2004)

Thus, to sum up it can be said that, any development takes place at the city level, must take place at a neighborhood scale at first. It is worthwhile to consider that, it should be a closed eco-cycle model system in which all the scales need to be interlocked with one another, in order to reach the desired concept of sustainable development. Thus, strong integration could be started from the building scale until it reaches to the city scale, as shown in figure (2.5). The main objective of this closed loop is to integrate all the systems for water, waste and energy such as making use of sewage, in order to decrease the ecological footprint of any built environment (Lindström & Lundström, 2008). For that reason, this chapter discusses how can be the neighborhoods become sustainable.

So two critical steps should be considered, the first one shows how can neighborhoods be better defined and the second shows how can the sustainability be best articulated with neighborhood scale.

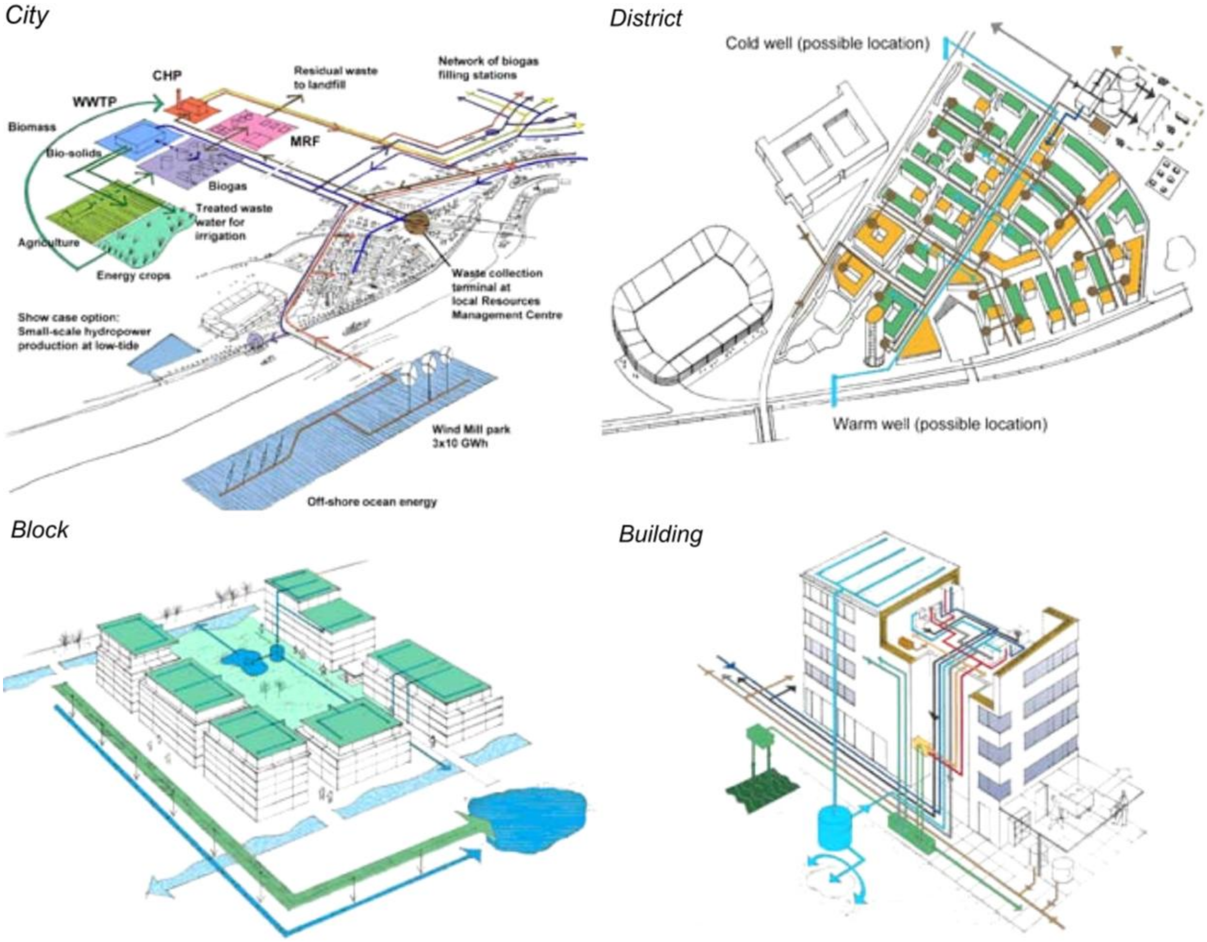


Figure (2.5): An eco-cycle model has been developed in the building, until it reaches the city levels
Source: (Lindström & Lundström , 2008)

2.4. <u>Defining Neighborhood:</u>

According to the study done by Kellett et al. (2009) that investigates the difference between the community and the neighborhood; the community can be defined as a place where residents can live, work, learn, shop and play. Also, the extent of the community can be defined by a radius of approximately 800 meters, as well as the walking distance should be a comfortable ten-minute walking distance from center to edge. On the other side, the neighborhood can be defined as a smaller subset of the broader community. It consists of a good mix of residential and non-residential buildings and land uses within a radius of approximately 400 meters, as shown in figure (2.6). It's worth mentioning that, on the scale of the neighborhood, the walking distance should only be a comfortable five minute from center to edge.

Figure (2.6): Walking distance within neighborhoods and communities
Source: (Kellett et al., 2009)

Moreover, it must be mentioned that, there are also three different facts and approaches to define any neighborhood. The first one has been attempted to describe the neighborhoods in relation to their spatial features, in particular population and building densities, as well as travel times for services. As, it is worthwhile to consider that, its boundaries were defined to be self-sufficient, as well as ensure the proximity of a dwelling to service the daily basis of its residents. Also, the population size was defined to be limited to about 1,000 families with close social relations between them. While, the second approach has been attempted to define the neighborhoods, according to the activities that are suited to them. The last approach has been attempted to define the neighborhoods in relation to the expectations around the nature and quality of social relations which presumed to be generated by neighborhood (Smith et al., 2006).

2.5. <u>Defining Sustainable Neighborhood:</u>

As mentioned before that, planning for sustainable urbanization has started by designing the new residential neighborhood, which has a key role in promoting the future urban sustainability and responding to the major trends in the world that affect in cities especially in the developing world. Furthermore, researches over the past decades have also confirmed that residential neighborhood form can have a great impact on the physical health, accessibility, crime, safety and social interactions. Thus, it is widely recognized that; the housing policy has become increasingly oriented towards ensuring residents to live in what could be termed ‘‘Sustainable Neighborhoods’ not only low in poverty and low in crime, but walkable, transit served and accessible to a wide variety of services and facilities (Talen & Kochinsky, 2010).

From here, the definition of sustainable neighborhoods was originally developed by Al- Hagla (2008) as “meet the diverse needs of existing and future residents, their children and other users, contribute to a high quality of life and provide opportunity and choice. They achieve this in ways that make effective use of natural resources, enhance the environment, promote social cohesion and strengthen economic prosperity”. Others argued that; the common vision for any sustainable neighborhood is to be socially cohesive, environmentally sound and economically viable in providing a high quality of life for all residents (Kellett et al., 2009). From another perspective, the study by Falk & Carley (2012) concluded that; the neighborhood sustainability is about how buildings and the spaces around them work together. As, it is about the functional aspects of buildings and spaces, their design, quality and aesthetics all work together to shape the urban built environment and influence local social and cultural identity. Consequently, it is quite important to understand that, a sustainable neighborhood is not just a string of sustainable houses, or a sustainable transport system, but it’s the combination of all of these and many other sustainability objectives across a wider scale.

2.6. Principles of Sustainable Neighborhood:

Moreover, Kellett et al. (2009) suggested that, there are numerous principles that guide the development of any sustainable neighborhood. Among those principles are:

- Ecological: The neighborhood must be developed and managed in a fashion that preserves and restores the natural environment for the benefit of human, animal and plant inhabitants. It should create a balance and mutually supportive circle of interaction between both the built and natural environments. Additionally, it should be designed and developed to emulate nature, as well as to maximize the benefit of natural systems such as the wind, the water flows, the sunshine and the absorbency of land.

• Efficient: It's worth mentioning that, each neighborhood should take the responsibility for the efficiency of its practices, as it should achieve the best use and correlation between the land, water, energy and waste disposal services and resources. Consequently, all the public and private organization in it should pursue in a manner that maximizes the efficient utilization of resources while minimizing their environmental effect.

• Complete: The neighborhood should provide its residents with the essential elements of the daily life, as well as make them close enough to where they live.

• Livable: The neighborhood must also provide its residents with high quality social, cultural, recreational and educational opportunities in a healthy environment that encourage well-being.

• Diverse: From another side the neighborhood should also include a mix of different opportunities, such as a range of housing choices, shops and services, commercial, industrial, as well as institutional employment opportunities.

• Compact: They connect residents with jobs and services through a variety of different pathways.

• Resilient: The last principle, assured that a truly sustainable neighborhood must have a built-in capacity to respond to any changes happen in the social, environmental and economic conditions, such as populations increase, global and regional economic changes, climate change and environmental phenomenon.

2.7. Sustainable Neighborhood Themes:

In general, to sum up it can be said that; a sustainable neighborhood is a form of a traditional neighborhood, which should be diverse, compact, complete and ultimately more satisfying. In addition to that, it should be well connected, safe, accessible, as well as pedestrian based and not car-dependent (Bodenschatz & Janke., 2008). Moreover, the study by Kellett et al. (2009) concluded those highly interdependent themes of any sustainable urban design into nine themes, as proposed below in table (2.1).

Them	Definition
Land	This refers to the efficient spatial arrangement of land uses in order to sustain human populations. Thus, in the sustainable neighborhoods, land can be used efficiently to accommodate the diverse places of dwelling, such as work, education and entertainment.
Mobility	This refers to the degree in which people have access to jobs, services and activities. The sustainable neighborhoods should provide mode and route options for residents to move easily between dwellings and places of work, learning, shopping by using green transportation which has less impact on the environment.
Energy	This mainly refers to the demand, supply and distribution of energy to power machines, buildings and vehicles. To reach more sustainable neighborhoods, energy demand should be reduced as well as increase opportunities to meet the demand with renewable energy and low emission sources. In addition to that, efficient distribution systems should also be used such as community or district energy systems.
Housing	It's worth mention that, sustainable neighborhoods should include an appropriate mix of housing types, sizes and density; resulting in diverse, safe and socially active places to live. This refers to the affordability and diversity of the housing stock critical to a socially and economically diverse society.
Natural Habitat	This refers to the ecosystems which support the natural development of plant and animal populations. As it is widely known that, removing habitat has negative impacts on the balance of the natural systems. So that, sustainable neighborhoods should protect, enhance or restore habitat of sufficient quality and quantity to support locally significant plant and animal species.
Water	It refers to the hydrologic cycle, which include precipitation, surface water and ground water. Thus, more sustainable neighborhoods should carefully manage consumption of potable water and treatment of wastewater to protect and restore the natural hydrology cycle, including aquatic ecosystems.
Food	This refers to the ability of providing a good access to secure, local food production. So sustainable neighborhood should support local food production, also should reduce dependence on imported food, thus in order to reduce the amount of energy transportation used to distribute food.
Waste	This refers to the best using of the organic waste in Pyrolysis process and converts it to energy. Sustainable neighborhoods can meet the annual energy demand by biogas energy produced from both dry urban and agricultural waste in a compact Pyrolysis carbon harvester.
Materials	Sustainable neighborhoods should promote the reuse and recycling of buildings and materials. In addition to the careful consideration for the source of the materials and their life-cycles. Thus, sustainable materials refer to the inputs martials or the used materials that have a big effect on the built environment in a neighborhood.

Table (2.1): Sustainable neighborhood themes
Source: (Kellett et al., 2009), adapted by the author

From another point of view, the study by Kellett et al. (2009) also demonstrated that, in order to achieve the performance evaluation of any development relative to a sustainability goal, it is preferable that the respective development achieves balanced performance across different indicators, as shown in figure (2.7). As, it’s widely agreed that, these indicators can prove a degree of integration of different aspects that take part towards achieving a certain sustainability goal. More specifically, they can serve to measure and monitor progress towards achieving explicit sustainability goals. It is worthwhile to consider the relation between these themes and their associated goals and indicators, as they are closely influencing each other. The following table (2.2) shows the goals and indicators, which mostly related to the previous nine themes.

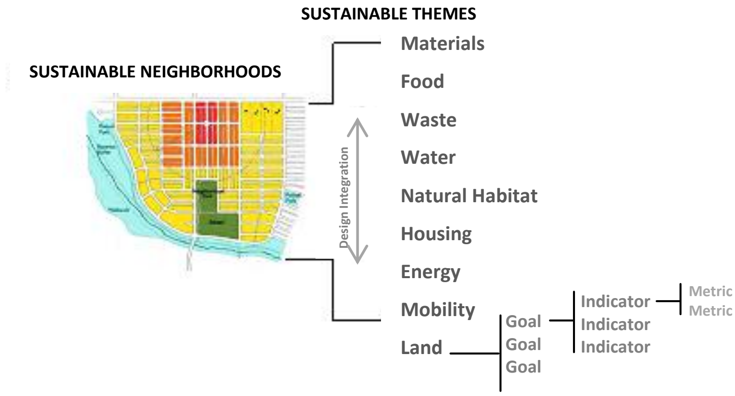


Figure (2.7): Relation of themes, goals, indicators and metrics in a sustainable neighborhood
Source: (Kellett R. &et al., 2009).

Them	Goal	Indicators	
		Indicator A	Indicator B
Land	Achieve compact development	Daily Destinations Proximity	
	Provide a diversity of land uses	Land-Use Diversity & Civic Amenity Proximity	Open Space Proximity
Mobility	Support transportation choice	Transit Proximity	Pedestrian Route Connectivity
Energy	Reduce energy demand	Building Energy Consumption	
	Use energy from renewable and low emissions sources	Renewable Energy Generation	
Housing	Accommodate diverse household types, incomes	Dwelling Diversity	Housing Affordability
Natural Habitat	Preserve, restore, enhance, create natural habitat areas	Natural Habitat Preserved	Natural Habitat Preserved, Restored, Enhanced, or Created
Water	Reduce potable water demand	Potable Water Consumption	
	Protect natural hydrology	Impervious Surface Intensity	Natural Hydrology Protection
Food	Preserve, restore, create food production	Farmland Preserved	Growing Space Preserved, Restored, Enhanced
Waste	Reduce the amount of waste	Construction Waste Management	Reuse of organic waste
Materials	Reduce the amount of material conservation	Use recycled Materials	Use materials from unconventional sources

Table (2.2): Sustainable Neighborhood Goals and Indicators
Source: (Kellett et al., 2009) adapted by the author)

2.8. Design Principles of Each Them of Sustainable Neighborhood:

As mentioned before, there are various forms of interdependent elements of any sustainable urban design. Each corresponds to one of those basic systems that support all the urban functions. The following part discusses the design principle of each one of these elements and their interrelationships. In order to provide a range of tactical measures that can be taken to maximize their individual contributions to sustainability.

2.8.1. Land-Use System:

It was stated by Bodenschatz et al. (2008) and Kellett et al. (2009) that, land-use system is a system which promote the diverse and combination of uses within a given area. It can state that, the sustainable neighborhood should be self-sufficient with its daily services in close proximity to residential housing. Also, the study by Kim (1998) demonstrated that, it should give its residents the ability to dwell, work, exercise and apply their needs within walking distance. In general, such integration of uses can mainly influence the economic vitality, social exchange, minimizes the energy consumption rate, as well as has a great impact on the sustainable development strategy. As, it was proved in the study done by Allen & McKeever, (1996) that, having a mix of shops and community services available within a neighborhood, reduces the amount of travel needed to reach them. Consequently, land-use should be classified, designed and regulated through zoning for mixed uses growth. The Swiss Village in Masdar City represents one of the best examples that show the variety of uses within the same area, as shown in figure (2.8) (Beglinger & Siegel, 2010).

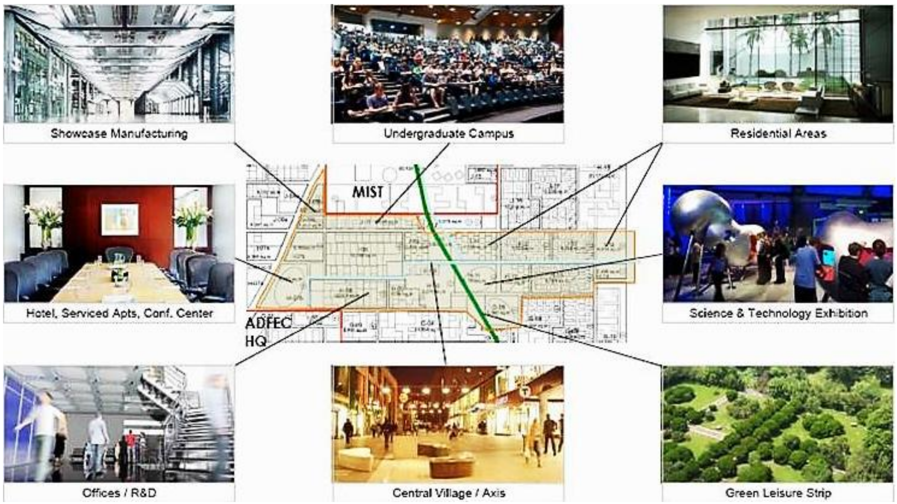


Figure (2.8): Swiss Village in Masdar City
Source: (Beglinger & Siegel, 2010)

2.8.2. <u>Mobility System:</u>

After the land-use diversity and mix, an integrated sustainable mobility network design represents one of the most important elements which determinants the neighborhood efficiency (Colette et al., 2009). It's worthwhile to mention that, there are some approaches and studies concentrated first on the importance of the proper designed of street network, in order to reach the sustainable urban form. This means that, any urban form should first promote the concept of the interconnected street networks. This may be extended to the reason that; the street pattern heavily influences how conveniently and economically people can move within a neighborhood (Allen & McKeever, 1996). Consequently, in general the streets should be designed to support the needs of pedestrian and bicyclists over car drivers, also should include green spaces, as shown in figure (2.9). It is also critical to emphasize that, safe and secure bike parking should be available throughout the neighborhood, as shown in figure (2.10-2.11) (Bodenschatz et al., 2008).

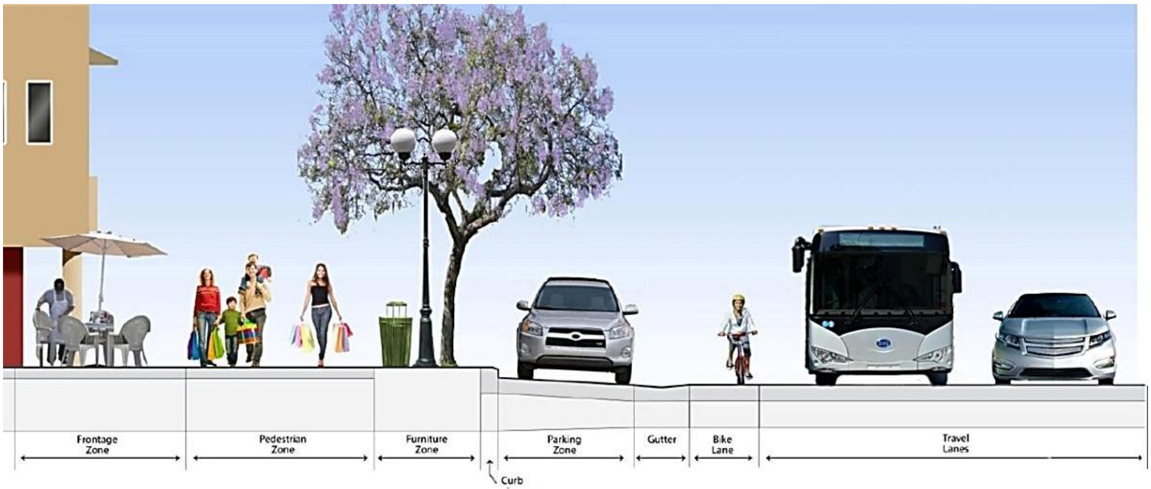


Figure (2.9): Example of complete street
Source: (Broward Metropolitan Planning Organization, 2011)

Figure (2.10): Example of bike parking
Source: (University of Michigan, 2014)

Figure (2.11): Example of bike parking
Source: (AUTO-MART, 2013)

Other approaches concentrated on expanding non-motorized local mobility options and public transportation systems that utilize alternative fuels, vehicles and fuelling infrastructures. As it is widely proved that, transportation fuel consumption accounts for a large percent of total oil usage. Added to that, almost over 65 per cent of transport fuel is used for personal motor vehicles. This heavy dependence on the private automobiles has led to unsustainable urban growth, thus the local governments need to support a shift from private to public and non-motorized transport for daily commuters. This strategy has the potential to contribute to the reduction in fossil fuel use and lower GHG emissions (McGeough et al., 2004). On the other hand, it's worth mentioning that, those alternative public transportation systems should be safe, affordable, flexible, as well as reduce emissions and noise pollution (UN-HABITAT & UNEP, 2009). It is also worthwhile to mention that, they should be well connected and available within the preferred walking distance which is the 400m (Kellett et al., 2009). One of the best examples that tried to achieve a sustainable mobility network by providing clean public transportation network within the preferred average walking distance, is Masdar City. As, In Masdar City the mobility network is designed to make any residents not to walk more than 800 m (approximately 10 minutes walk) to an MRT station, also not more than 400 m (approximately 5 minutes walk) to a bus stop, as shown in figure (2.12).

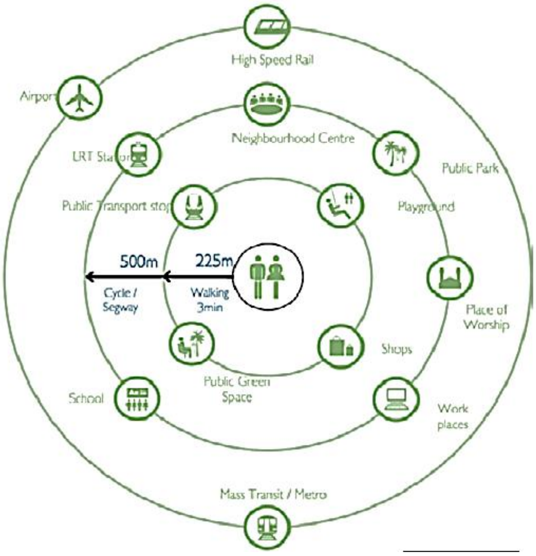


Figure (2.12): Masdar city street network
Source: (Masdar –Mubadala Company, 2010)

Hence, to sum up it can be said that, one of the key studies to reach sustainable urban form is the feasibility of using alternative public transportation systems, as well as improve mobility networks in general (McGeough et al., 2004). To define which one is preferred for a certain residential project, the following part shows different alternatives for the transportation types which leading the way in sustainable urban form.

1) <u>Long-distance Transportation Systems:</u> It's worthwhile to mention that, there are numerous economical transportation alternatives that can be used for long distances. Among those systems are:

• The light rail and streetcar systems; those will continue to present a more sustainable option than private automobiles and expansive freeway systems (Railway Technology-Kable, 2013). Figure (2.13, 2.14) shows example of The light rail and streetcar systems.

Figure (2.13): Example of Streetcar in Portland
Source: (TreeHugger, 2014)

Figure (2.14): Example of light rail lines
Source: (Railway Technology-Kable, 2013)

• The second system is the bus rapid transit; this system can combine the quality of rail with the flexibility of buses, as shown in figure (2.15). It's worth mentioning that, it is faster than conventional bus lines, but less costly than light rail (Maryland Department of transportation, 2013).

Figure (2.15): Conventional bus and rail transit in Maryland's transportation network
Source: (Maryland Department of transportation, 2013)

• Another system can be used which is the high speed commuter rail, as show in figure (2.16). It's worth mentioning that, this system has demonstrated as economic development potential associated with rail projects (Chiangrai Bulletin, 2013).

Figure (2.16): Hi-speed rail between Bangkok – Chiang
Source: (Chiangrai Bulletin, 2013)

Actually, all of these mass transits in the form of buses or rail are rider-friendly, save energy, reduce emissions, as well as they can reduce the need for parking areas (Maryland Department of transportation, 2013).

2) Intelligent Transportation Systems: After using the different alternatives for the long distance, the intelligent transport systems should be demonstrated, in order to provide a greener and safer transportation (ORing Industrial Corp, 2013). Studies and research show that, intelligent transport systems services are designed to optimize transportation times and fuel consumption. Their concept was defined as adding information and communications technology to transport infrastructures and vehicles in an order to improve their safety, reliability, efficiency and quality. Furthermore, this system includes telematics and all types of communications in vehicles, as well as between vehicles and fixed locations, as an example shown in figure (2.17, 2.18) (Engaged IT for the CIO, 2011).

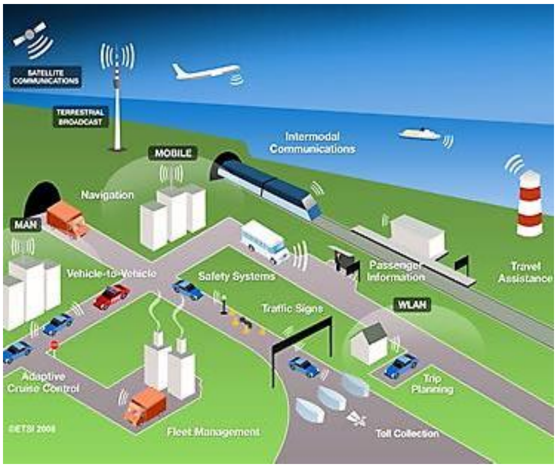


Figure (2.17): Intelligent Transport Systems
Source: (Engaged IT for the CIO, 2011)

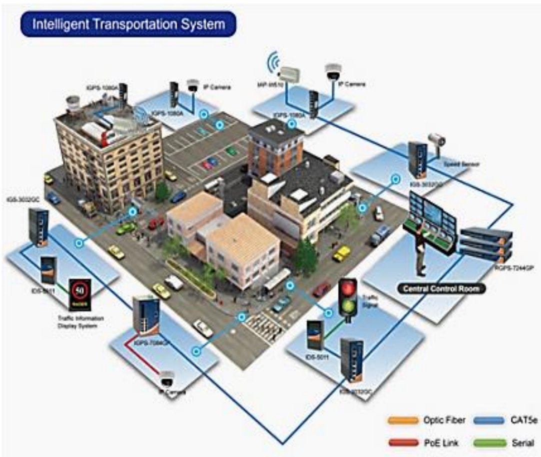


Figure (2.18): Transport Systems
Source: (ORing Industrial Corp, 2013)

Besides, it also worthwhile to consider that, at these intelligent transport systems, there are other more flexible new transportation technologies should be explored for intermediate distance travel between urban nodes and residential neighborhoods. From those new transportation technologies are the electric vehicles, as shown in figure (2.19). As it is widely agreed that, the future of the world mobility is the electric cars, as well as it plays a vital role in the development of any sustainable mobility. Besides the electric cars, there are also different modes of intelligent transportation, which has already explored such as, the E-Trike ZED, as shown in figure (2.20). As well as, the personal rapid transit (PRT) which has been used in Masdar, as shown in figure (2.21). All of those technologies can be used as a type of new intelligent transportation systems which can help in reaching healthy environment, as well as reduce emissions.

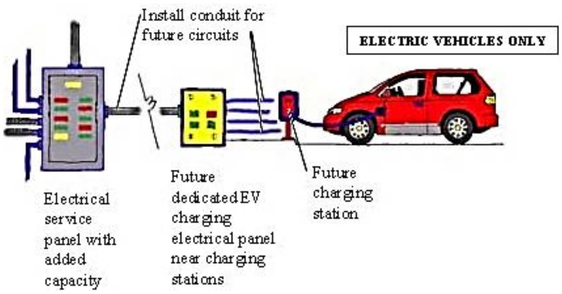


Figure (2.19): Example of electric car
Source: (Santa Monica Office of Sustainability and the Environment, 2014)

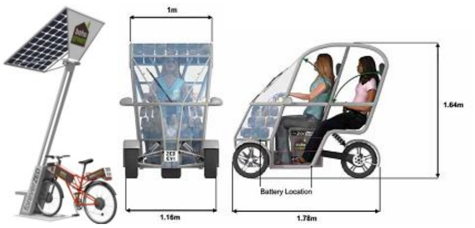


Figure (2.20): E-Trike ZED
Source: (Zedfactory, 2014)

Figure (2.21): The personal rapid transit (PRT)
Source: (Tompkins, 2009)

2.8.3. Energy Efficiency:

It is worthwhile to mention that, although energy sector is one of the most fundamental drivers of social and economic development in the developing countries, it does not take the first priority in the designing of any community. As it is obvious that, the use of energy, the types of energy used and the lack of access to sufficient energy have far reaching significant signs, as well as the energy consumption has become increasingly scarce and more expensive. In addition to that, it also has far reaching implications for a city’s economic development, its environmental health and its social development. From the other side, the wasteful consumption of the fossil fuel resources becomes the major cause of excess carbon dioxide emissions in the atmosphere, which is the main cause of the climate change. Consequently, at the present time the energy sector and carbon mitigation have to be at the center of any sustainable development strategy. As, there are a lot of potentials to greatly improve energy efficiencies and reduce carbon emissions in many developing countries which have a substantial industrial base (UN-HABITAT & UNEP, 2009). In general, it was confirmed that cities which implement sustainable energy and climate action plans will reduce their vulnerability to energy scarcity and to energy price rises. They also will have less traffic congestion, cleaner air and lower energy input costs (Tereci et al., 2010).

Hence, it can be concluded that all the cities should depend on energy system conclude in a whole energy system, which must work together to achieve the best performance (McGeough et al., 2004). This system requires a very different approach, which is mostly discussed on three steps which are the energy consumption, energy distribution and finally energy generation, as shown in figure (2.22). So, wherever possible, the energy service needs of the users and the city should be first reduced. Then, finding clean sources for the energy which do not pollute the environment should be provided. Then find good ways to deliver the energy to the users in an efficient way. This will allow for rapid development and implementation of strategies that will assist cities in achieving not only energy, but overall sustainability (UN-HABITAT & UNEP, 2009). The following chapter discussed in details the design principles of each part, while the following part gives only a short description for each part.

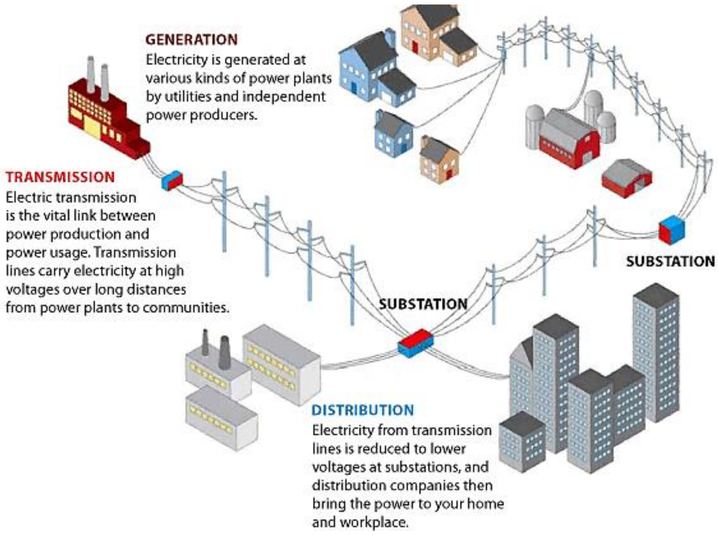


Figure (2.22): Example of connecting Energy system
Source: (InContext, 2010)

- <u>Energy Conservation:</u>

The main goal of the energy conservation methods is to reduce the rate of consumption of fossil fuels. The reduction of the energy consumption should not only apply in the operation stage, but also in their construction. In addition to that, substantial energy savings can also be achieved by ensuring passive techniques which have taken large attention in the recent years. As, it is quietly important to minimize the reliance on artificial cooling and heating devices that rely on electricity. This can be achieved by adopting different strategies such as orientation, massing, window positioning and sizing, as shown in figure (2.23) (Kim, 1998). These concepts will be explained in details in the next chapter.

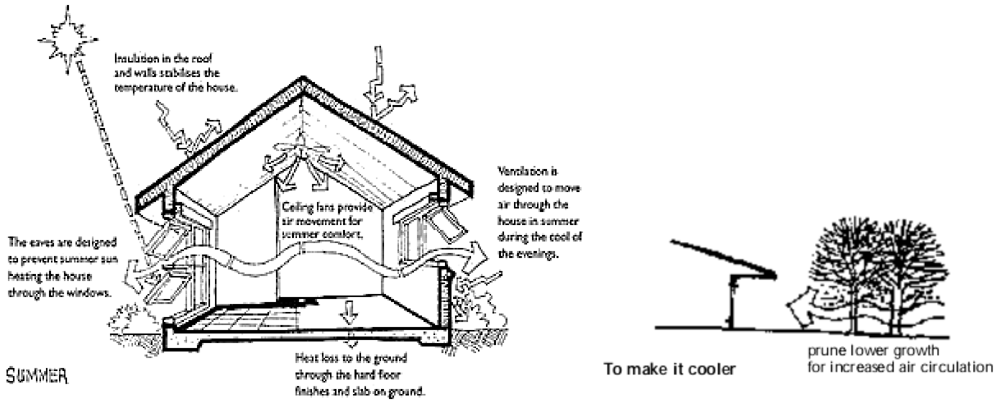


Figure (2.23): Different passive techniques
Source :(Robertson, 2009)

- <u>Energy Distribution:</u>

It was stated by Baker & Steemers (2005) that, the local feasibility of developing district energy systems to distribute thermal energy to consumers should be considered. As, it is widely agreed that, the distribution of heat around buildings or sites will inevitably lead to some losses. Thus, it must be mentioned that there is a big demand for managing the distribution of energy, in order to minimize these losses. Furthermore, the policy-makers should consider smart grids, distribution management and end-user energy delivery in the early stages of urban policy formation. As, investing in the smart grids can improve demand response, delivery of efficient energy and integration of variable renewable resources (Schiller & Fassmann, 2010). The following picture (2.24) shows example of smart grid ecosystem.

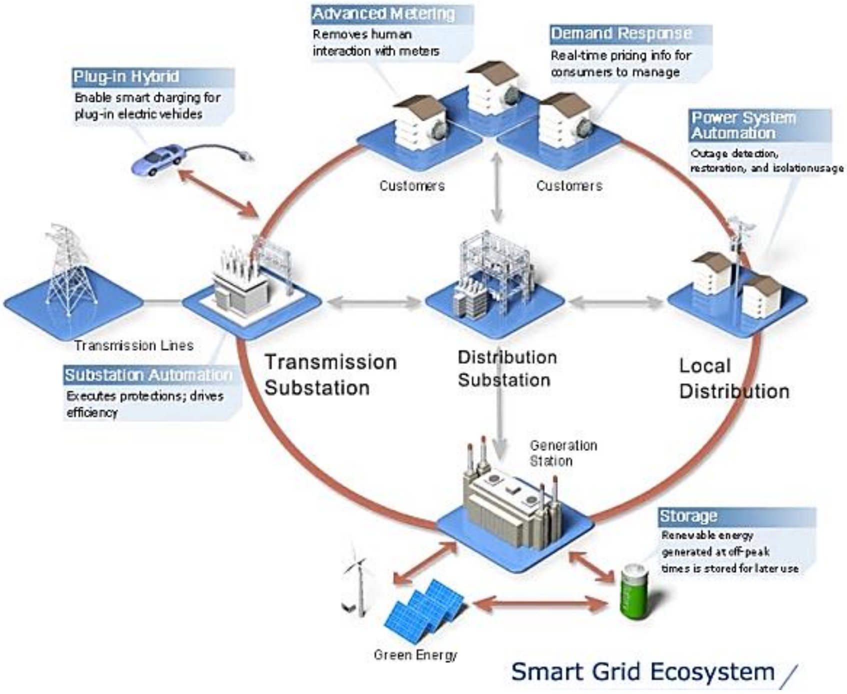


Figure (2.24): Smart Grid Ecosystem
Source: (Moxa, 2011)

Energy Generation;

Energy generation should be part of integrated approaches that include energy distribution system, which can help to increase the overall share of renewable energy sources. Furthermore, energy generation policies at any sustainable city should include plans for electricity and heat generation through local renewable energy sources, in order to reduce their impacts on the environment. Such these integrated approaches are not new, since several cities around the world have already implemented it, in order to avoid the greatest challenge such as the climate change. They are different forms of renewable energy sources which can be used off-site or can be represented as metropolitan sources. The most common forms are the solar photovoltaic, the wind turbines, geothermal and biogas, as shown in figure (2.25) (McGeough et al., 2004).

Figure (2.25): Different forms of renewable energy resources
Source: (Mary & Frank, 2014)

In addition to that, there are options of the renewable energy sources, which can be used as on-site energy supply sources. The most preferred applications of on-site renewable energy sources are the rooftop PV, the solar water heating, as well as parking lot-based on PV systems, as shown in figure (2.26,2.27) (Marszal & Heiselberg, 2009).

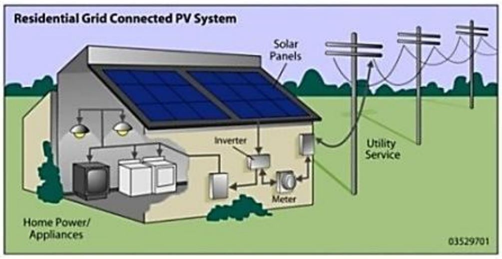


Figure (2.26): Residential Grid connected PV system
Source: (Energy home, 2013)

Figure (2.27): Parking lot-based on PV systems
Source: (Matus, 2013)

2.8.4. <u>Water Management:</u>

It's worth mentioning that, worsening drought with its close relation to the rapid population growth in the recent years have called sharp attention for the need to make more efficient use of the water supply. Accordingly, communities have led the charge in improving water efficiency through regulations. Besides, additional methods for water conservation should also be applied in order to reduce input, output, or even both. Those methods used to achieve specific goals in order to apply water conservation management system in any city (Colorado, 2009). The following points conclude those goals into:

- Reduce community per capita water use while retaining attractive landscapes.
- Protect ground and surface water supplies from unsustainable depletion.
- Eliminate unnecessary waste in water use practices.
- Reduce wastewater treatment volume and associated municipal expenditures.
- Promote the increased use of harvested and recycled water for irrigation need.

Therefore, it can be said that, any community interested in improving water efficiency should consider education and incentive tools in conjunction with regulations as part of their overall strategy. They should introduce new technologies or practices such as rain gardens and installing water efficient appliances, in order to reduce water use. On the other side, water supply systems and fixtures should be well selected such as the flow faucets, small toilet tanks and also bio composting toilets, in order to reduce consumption and waste. As well as, wherever possible, native plants should be used, in order to reduce water consumption. As, these plants will have adapted to the local rainfall levels and eliminating the need for additional watering (Colorado, 2009). See figure (2.15) to show water conservation system. On the other hand, reuse water on the site should be promoted. As, the concept of the water consumed in buildings was originally classified by Colorado (2009) in two types: grey water and sewage. Grey water is produced by activities such as hand washing, it is not used for drinking-water activity. In fact, it can be recycled within a building, in order to irrigate plants or flush toilets. It's worth mentioning that, well-planned plumbing systems should facilitate reuse and recycling water. The following figure (2.28) shows an example of decentralized waste water treatment (Paradigm environmental strategies, 2010).

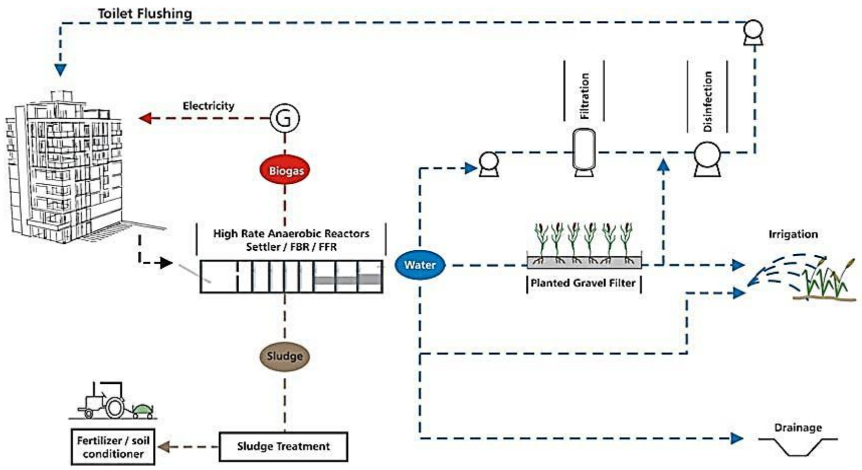


Figure (2.28): Reuse Water on-Site
Source: (Paradigm environmental strategies, 2010)

2.8.5. <u>Natural Systems:</u>

As described previously, it refers to the ecosystems that support the natural development of the natural systems. So that, sustainable neighborhoods should protect, enhance or restore habitat of sufficient quality and quantity to support locally the natural systems (Kellett et al., 2009). From another side, it was stated by McGeough et al. (2004) that, all sustainable urban designs must begin with a thorough comprehension of the immediate physical environment and of the natural forces that shape it. As it is widely known that, sustainable design should ensure that the location and character of urban development which minimize all the impacts on the environment, while it harnesses the natural forces to reduce material and energy consumption. Thus, the study argued that there are five natural subsystems that must be examined in order to comprehend the natural context for urban development, those are:

- Land: The first consideration in the urban design process is the carrying capacity of land and its suitability for development. This capacity and suitability will depend on various macro and micro-scale considerations which include: topography, geology, soil composition and permeability. Also depend on their interactions with water elements in the natural landscape. Understanding all of these interactions is essential for all small-scale and large-area development sitting determinations.
- Water: The second essential component of concern natural habitat includes all the surface waters and watercourses, groundwater in underground aquifers, floodplains and wetlands. Water quality is directly affected by all of these factors like: natural direction of flow, velocity, circulation and carrying capacity. So, all sustainable urban development must be designed to accommodate the natural characteristics of all of these water elements.
- Climate: Another concern, which is the macro-climate considerations such as the annual average cloud cover, the sunshine, ambient air temperatures, precipitation and air flows. All of these factors have a significant effect on the habitability of any natural area, as well as they have a significant impact on the built urban environment. Sustainable design will help to mitigate the impacts of climate extremes on the built environments while they harness the natural forces to reduce energy consumption.
- Habitat: In natural habitats, plants and animals rely on the unimpeded flow and interaction between these three subsystems for food, shelter and protection. As these conditions are maintained, diverse animal and plant life flourishes. Urban development patterns directly affect habitat and the natural web of life through the direct or indirect manipulation of land, water and air resources.
- Air Quality: Air quality is a major environmental health issue, particularly in the summer when an inversion layer traps pollutants close to the ground. Vehicles and other mobile sources powered by combustion 70% of the air pollution. Other problematic air pollutants include the emissions of carbon monoxide, hydrocarbons, sulphur dioxide and oxides of nitrogen. Sustainable design should reduce the rate of the consumption, thus in order to reduce the air pollution and achieve a healthy environment.

2.8.6. Waste Management:

It was proved by McGeough et al. (2004) that 28% of this waste is now recovered and recycled or composted, 15% is used for fuel and the remaining 57% is disposed of in landfills. These landfills are anaerobic oxygen-free environments, where methane is produced by the bacterial decomposition of the organic materials. The study also explained that the potentials of the landfills, help in reducing greenhouse gas emissions and the danger of explosion. Besides, landfill gas-to-energy projects can reduce the cost of compliance with regulations, also can displace electricity produced by fossil fuelled-central power plants, as well as can produce power that can be sold as green products. Some other studies and research show that in many urban projects about 1/4 of the annual energy demand can be met by biogas energy produced from both dry urban and agricultural waste in a compact Pyrolysis carbon harvester, as shown in figure (2.29) (Zedfactory, 2014).

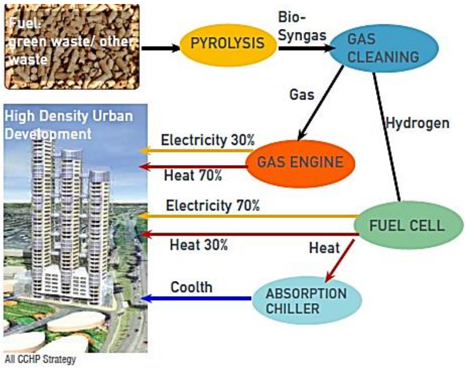


Figure (2.29): Example of waste management process
Source: (Zedfactory, 2014)

From here, it can be mentioned that anything that is purely organic is absolutely ideal for the Pyrolysis process such as: wood chippings, palm husks. Also, mixed waste which produced from homes or commercial can be used such as the food, textile, paper and card. Besides, there are also other organic based products such as: plastics, film, rubber, or other materials which derived from oil or other fossil fuels. On the other side, the animal waste, meat, sewage sludge all of these can be represented as the ideal candidates for treatment with Pyrolysis (Zedfactory, 2014). According to Zedfactory (2014), the following part explained briefly the Pyrolysis gas process:

- Direct use: First, on-site at the point of production, the gas can be cleaned and fed directly into a Gas Engine, Hydrogen Fuel Cell. Also, it can be used directly for industrial processes or cooking for example. This option requires preferably an electrical and thermal load situated nearby, to approximately match the output of the engine.

- Storage and Distribution: The second method that the biogas can be compressed and liquefied much in the same way that petroleum gas. It can also be processed to a transport grade gas, which is capable of replacing petrol in converted vehicle engines.
- Virtual BioGas: The last method that, the biogas can be processed, cleaned, returned back into the national gas network and purchased by consumers elsewhere. Where farmers can benefit from the proximity of existing waste streams without being hampered by the distance to the energy end user, as shown in figure (2.30). Where, the fuel cells that located in the heart of the city could take the biogas from the grid and convert it in a highly efficient process into heat and power where it's most needed, as shown in figure (2.31). In general, this process can offer both economic and environmental quality benefits for the urban communities that select to harvest the gas.

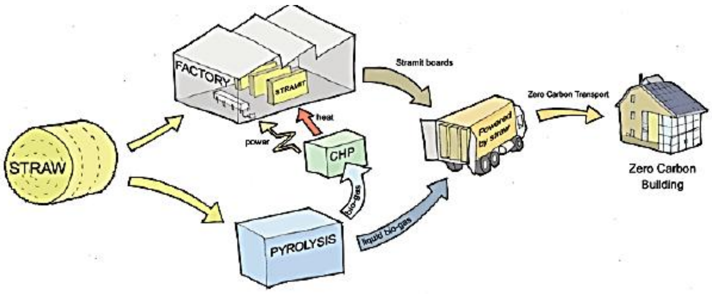


Figure (2.30): Waste processing systems
Source: (Zedfactory, 2014)

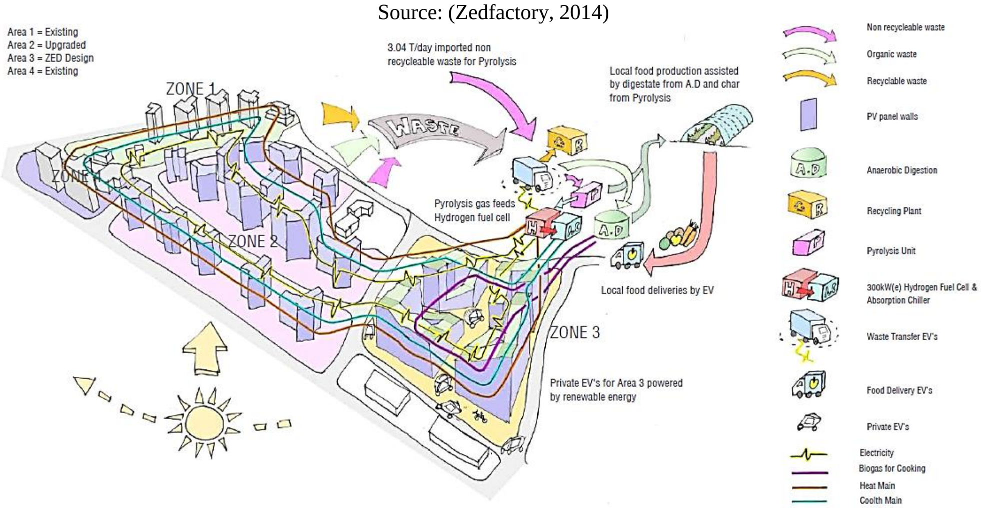


Figure (2.31): Zero carbon waste strategy applied to urban high density master plans
Source: Source: (Zedfactory, 2014)

2.8.7. <u>Materials Conservation:</u>

The study by Kim (1998) proved that, the production and consumption of building materials have diverse implications on the local and global environments. The study also argued that the transporting building materials, extraction, processing and manufacturing them, all cause ecological damage and cause environmental problems. From the other side, the study also explained that one of the most effective methods for materials conservation is to make use of the resources that already exist in the form of buildings. Many building materials are easily recycled into new materials, thus this means that the buildings that have to be demolished should become the resources for new buildings. As, these products reduce the need for new landfills and preserves the energy embodied in their manufacture. The following figure (2.32) shows examples of some buildings which used unconventional recycled material sources, such as recycled tires, pop bottles and agricultural waste, are readily available (WebEcoist-Going Beyond Green, 2014).

Figure (2.32): Example of recycling materials like: tires, wood pallet, bottles
Source: (WebEcoist-Going Beyond Green, 2014)

2.8.8. <u>Food System;</u>

The study issued by McGeough et al. (2004) proved that, the repercussions of the industrial local food systems should be wide-ranging, as they have great effect on:

- Environmental consequences such as erosion and loss of biodiversity.
- Social ramifications, such as epidemic rates of diet-related diseases.
- Inequitable economics, in which farmers bear a disproportionate amount of the production risk and capture only a fraction of the food dollar.

The study also explained that the food system initiatives, decision makers and policies should typically be clustered to use excess local organic food rather than using unhealthy foods. Thus, increasing the awareness of the strong connections between food, public health, local economic development and environmental stewardship has a big effect on exploring ways of integrating the food system into their land-use, open space and economic development planning. From another perspective, residents can also be provided with a host of information on local farms, organic supermarkets and farmers markets. They can easily be enabled to get involved in the greening roof process. In general, it was proved in the study by Zedfactory (2014) that, the community should be arranged to be community gardens with food growing and composting facilities. Besides, it should provide free spaces and the green roofs for their residents. Zedfactory is one of the best examples that show how the community can provide a system of local organic farm for its resident, as shown in figure (2.33).

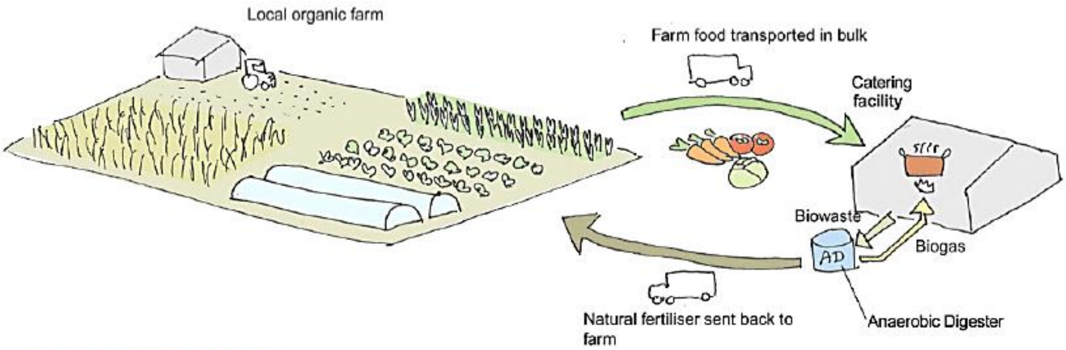


Figure (2.33): Diagram shows the local organic farm

Source: (Zedfactory, 2014)

2.8.9. <u>Housing:</u>

As mentioned before, that sustainable neighborhood should include an appropriate mix of housing types, sizes and density, resulting in socially active places to live. This mainly referred to the affordability and diversity of the housing stock. (Kellett et al., 2009). Besides, the study done by Schwartz (2010) demonstrated that, the household should be able to meet the residents' basic needs on a sustainable basis, as well as should be currently diverse, safe and socially active places to live. From other hand, any sustainable neighborhood should also provide reasonable, adequate household in the standard location for lower or middle income households besides the sustainable household for higher income. Also, they should upgrade the energy efficiency and sustainable materials in the low-income housing, so they could achieve more green affordable housing. To sum up, it can be said that the green household is a term that refers to reasonable housing stock that mix the sustainable features, as well as have lower energy cost and improved health.

2.9. Sustainable Neighborhood Indicators & Assessment Tools:

From another perspective, according to the importance of the urban sustainability, which has been increasingly appreciated, it becomes essential to apply certain policies in order to achieve any sustainable development plan. It is worthwhile to mention that, efforts should be done to effectively integrate the aspects of environmental protection, economic equity and social well-being in any development plan. Besides, this also requires the existence of a good monitoring system to evaluate their impacts. Consequently, at the present days each government should choose its own indicators or its own sustainability assessment tools to monitor and support their policies effectively. As well as, decision makers should depend on those systems, in order to support them in finding more sustainable solutions throughout the different stages in any urban development projects (Shen et al., 2010).

2.9.1. Urban Sustainability Indicators:

Many researches are approved that, through the using of indicators, cities can be classified to be sustainable or not. From here, a study done by Yigitcanlar & Dur (2010) explained that, the main role of the indicators is measuring the performance of urban communities. The study also demonstrated that, there was a common agreement that the indicators help in the performance assessment of the development and of the overall awareness of partnerships to improve economic, social and environmental well-being of urban settings. For that reason, at the present days several different indicators have been developed in different ways according to the required needs, the aim is same for all which is attaining urban sustainability.

Besides, another study done by Toudert (2008) showed that, there are numerous aspects that describe any indicator. As, any indicator should be represented, logic, as well as provided a good quality of data, sensitivity to ecological, social, economic. In addition to that, any indicator should be SMART (Specific, Measurable, Achievable, Relevant and Time-related). Some other studies consider that, the indicators should be clear, simple and have the possibility to change according to any regular updates. In general, the study done by Shen et al. (2010) concluded that, the urban sustainability indicators should be explanatory tools to translate the concepts of sustainable development into practical terms. Additionally, it should be a pilot tool to assist in making policy choices that promote sustainable development and performance how effective efforts have been. Furthermore, the study also assured that the selection process of indicators should selectively analyze the ones which produce the most accurate information about the status of practice and not be about gathering the information for all indicators. Accordingly, most of the local and national governments across the world have developed their own indicators to measure the urban sustainability performance according to their local or national priorities. As it is widely agreed that, there is no single set of indicators that suits equally to all cities or communities, although there are various lists of urban sustainability indicators. The study also showed that, there are some sets of comprehensive list of urban sustainability indicators which are promoted by international and regional organizations. Among those indicators are the United Nations (2007), the UN-Habitat (2004), the World Bank (2008), the European Foundation (1998), the European Commission on Science and Research (2000), as well as the European Commission on Energy Environment and Sustainable Development (2004). The following figure (2.34) shows an example of indicator named as “International Urban Sustainability Indicators List (IUSIL)”.

Category		Cities C1	C2	C3	C4	C5	C6	C7	C8	C9
Environmental										
En1	Geographically balanced settlement	✓	○	–	✓	○	✓	–	○	✓
En2	Freshwater	–	–	○	✓	○	✓	✓	✓	✓
En3	Wastewater	–	–	○	✓	✓	✓	✓	✓	✓
En4	Quality of ambient air and atmosphere	✓	✓	–	✓	✓	–	✓	✓	–
En5	Noise pollution	✓	✓	–	✓	✓	–	–	✓	–
En6	Sustainable land use	–	✓	○	○	✓	○	–	✓	○
En7	Waste generation and management	–	–	✓	✓	✓	✓	✓	✓	✓
En8	Effective and environmentally sound transportation systems	✓	–	–	✓	✓	–	–	–	–
En9	Mechanisms to prepare and implement environmental plans	✓	–	✓	–	✓	–	✓	–	–
En10	Biodiversity	✓	✓	✓	○	✓	–	✓	–	–
Economic										
Ec1	Consumption and production patterns	–	✓	○	✓	○	○	○	–	–
Ec2	Economic development	○	✓	✓	–	–	○	–	✓	✓
Ec3	Finance	–	–	–	–	–	–	–	✓	✓
Ec4	Water	✓	✓	–	✓	–	–	–	–	–
Ec5	Strengthen small and microenterprises	–	–	○	–	–	–	–	–	–
Social										
So1	Energy Access	–	–	✓	–	○	–	○	–	–
So2	Water Access	–	–	✓	✓	✓	✓	✓	✓	✓
So3	Education	○	○	–	✓	–	–	–	–	–
So4	Health	–	✓	–	✓	–	–	○	–	○
So5	Safety	–	–	–	✓	–	○	–	–	–
So6	Fire & Emergency Response	–	–	–	–	–	–	–	○	–
So7	Poverty	–	–	✓	○	–	–	–	✓	✓
So8	Transportation	✓	✓	✓	✓	✓	✓	–	–	✓
So9	Natural hazards	–	–	–	–	–	–	–	–	–
So10	Adequate housing	–	✓	✓	✓	–	○	–	–	✓
So11	Shelter	○	–	✓	–	–	○	–	○	✓
So12	Security of tenure	–	–	–	–	–	–	–	–	–
So13	Access to credit	–	–	–	–	–	–	–	–	–
So14	Access to land	–	–	✓	–	–	–	–	–	–
So15	Promote social integration and support disadvantaged groups	–	✓	✓	–	✓	–	–	✓	–
So16	Culture	✓	✓	○	○	–	–	–	✓	✓
So17	Recreation	–	✓	–	–	✓	–	–	–	○
So18	Availability of local public green areas and local services	✓	✓	○	○	✓	○	–	✓	○
Governance										
Go1	Participation and civic engagement	✓	✓	✓	–	–	✓	–	–	✓
Go2	Transparent, accountable and efficient governance	–	–	–	–	–	–	–	✓	○
Go3	Government	–	–	–	–	–	–	–	–	–
Go4	Sustainable management of the authorities and businesses	–	–	–	–	–	–	–	–	○

Keys: ✓ Included, ○ Similar, – Not included; C1 – Melbourne, C2 – Hong Kong, C3 – Iskandar, C4 – Barcelona, C5 – Mexico City, C6 – Taipei, C7 – Singapore, C8 – Chandigarh, C9 – Pune.

Figure(2.34): Example of urban sustainability indicators
Source: (Shen et al., 2010)

Moreover, at the neighborhood context, indicators can help to evaluate whether the local actions having the desired effects or not. Thus, the study by Toudert (2008) argued that, the neighborhood can use indicators to help in determining what conditions exist and whether the direction of the neighborhood is headed in consistent with community goals. As, indicators can allow a group to hold itself, its public officials, its funders and supporting institutions accountable to neighborhood goals. Finally, indicators can also be used as a reporting tool that can help build consensus for an action strategy. There is a good example that shows a new method for assessing the sustainability of urban neighborhoods which is named CAMESUD, as shown in figure (2.35)

Indicators for sustainable Urban Design

(1) Management and Quality of Services

- Committment and Sustainability Policy
- Management Plan
- Awareness Support and Concertation
- Integration of Sustainability Issues in Urban Documents
- Commissioning of Urban Systems
- Ease of Maintenance of Infrastructure
- Maintenance of Building Stock
- Waste Management of Neighbourhood
- Construction Site Impacts

(2) Urban Location Efficiency and Site Ecology

- Selection and Site Investigation
- Brownfields and Polluted Sites Redevelopment
- Requalification of Existing Urbanized Zones
- Preservation of Agricultural Land & Green Spaces
- Protection of Natural Ecosystems (Flora & Fauna)
- Improve Biodiversity and Site Ecology
- Site Integration: Respect of Relief and Natural Site
- Landscape View
- Prevention and Protection from Natural Hazards
- Reduce Site Disruptance during Construction

(3) Urban Infrastructure & Transport

- Accessibility & Connectivity of Neighbourh. to City
- Efficient Wastewater Management System
- Promote Non-Pollutant Transportation Systems
- Reduced Parking Footprint
- Pedestrian Areas & Intra-Connectivity of Neighbourh.

(4) Land Use, Urban Forms and Quality of Life

- Mixed Habitat-Working Areas
- Integrated & Diversified Urban Activities and Services
- Availability & Proximity of Parks and Leisure Spaces
- Remote Industry and Pollutant Activities
- Shared Use of Installations
- Compact Urban Design & Contained Development
- Sunshine and Solar Rights: Outdoors & Indoors
- Urban Porosity and Ventilation
- Urban streets, Public Spaces & Pedestrian Areas
- Building Envelope and Urban Typology
- Entrances to Neighbourhood and Buildings
- Cool Urban Surfaces and Pavements
- Integrated Vegetated Areas in Built-Up Areas
- Thermal and Wind Comfort in Outdoor Spaces
- Visual Comfort in Urban Open Spaces
- Noise and Acoustic Comfort
- Ecological & Sustainable Buildings
- Adaptability and Flexibility of the Neighbourhood
- Imageability, Sense of Place & Centrality
- Renovation of Existing Buildings & Open Spaces
- Urban Furniture

Indicators for sustainable Urban Design

(5) Efficient Use of Resources [Energy, Water, Materials]

- Energy-Efficiency of Urban Structure
- Energy-Efficient Buildings
- Urban Lighting
- Renewable Energy Use on Site
- Electricity Production on Site
- Stormwater Management
- Treatment of Rainwater and Greywater
- Conservation of Water for Irrigation
- Water conservation in Buildings
- Local Materials with Low Energy Content
- Recycled and Salvaged Materials

(6) Pollution & Environmental Loadings

- Quality of Air and Pollution Control
- Reduce Nocturnal Light Pollution
- Prevention of Pollution Hazards
- CO2-Emissions from Traffic & Built-Up Areas (GWP)
- Acidification Emissions (NOx et SOx)
- Photo-Oxidation Emisions (NO & NO2)
- Water Course Pollution

(7) Society and Culture

- Urban and Architectural Heritage
- Historical Sites and Monuments
- Social Mix and Population Density
- Quality and Variety of Housing
- Social Connectivity
- Accessibility to Hadicaped People
- Social Participation
- Population Density and Profile
- Eco-Education

(8) Economics

- Affordable Housing
- Support of local Economy
- Investment and Financial Impacts
- Life Cost Assessment
- Potential for Local Autonomy

Figure (2.35): A new method for assessing the sustainability of urban neighborhoods and is named CAMESUD
Source: (Toudert, 2008)

2.9.2 <u>Urban Sustainability Assessment Tools:</u>

As explained above, according to the wide acceptance of the sustainable urban development notion, finding an accurate way to assess and measure comparative sustainability levels of existing and future developments has become an important issue. There have been various studies which have proposed different methods for sustainability assessment. One of those studies is a study done by Yigitcanlar & Dur (2010) which concluded that, there are various sustainability assessment methodologies, models and tools developed so far, but only few of them have an integral approach that takes into account all of the environmental, economic and social aspects. In most cases the focus is on one of the three aspects, although it could be argued that they should serve supplementary to each other. Besides, another study done by Kyvelou et al., (2012) also concluded that, there numerous tools developed to assess the performance of eco-neighborhoods and provide guidance for their planning and design. Among those assessment tools are: Cascadia Scorecard, Leadership in Energy and Environmental Design for Neighborhood Development Rating System (LEED NB), One Planet Living (OPL), South East England Development Agency (SEEDA) Checklist, etc. (Yigitcanlar & Dur, 2010). In general, the overall goal of all of those is to have a common set of criteria and standards, which can typically embodied in the design guides in order to help professionals to design, construct and manage property in a more sustainable way. They should attempt to achieve continuous improvement to optimize the overall performance while minimizing the environmental impact. While in many cases, these criteria can be gain beyond the codes and the regulations in the countries in which they are used (Reed et al., 2009).

From a general point of view, lacking the guidelines and criteria which used to choose between these tools, is the main problem (Reed et al., 2009). As usual, the selection of assessment tools is performed by the analysts and usually depends on the time, date, as well as budgetary constraints. The process also depends on the qualifications of analysts and the range of tools accessible to them rather than on a solid theoretical basis or the context of the overall assessment. Moreover, a good understanding of the cultural, political, as well as economic context of the assessment or of the needs and values of the affected stakeholders should be taken in the consideration while selecting the tool (Gasparatos & Scolobig, 2012). Regarding those tools, the following part explains some examples of them:

- To BioRegional One Planet Living Framework

Kyvelou et al. (2012) explained that, this framework consists of ten principles which should govern sustainable communities, namely, zero carbon, zero waste, sustainable transport, sustainable materials, local and sustainable food, sustainable water, land-use and wildlife, culture and heritage, equity and local economy and lastly health and happiness. This approach can be easily used to help individuals and local stakeholders to examine the sustainability challenges and develop appropriate solutions. The One Planet Communities programme uses a set of common international targets against each of the 10 One Planet principles as shown in figure (2.36)

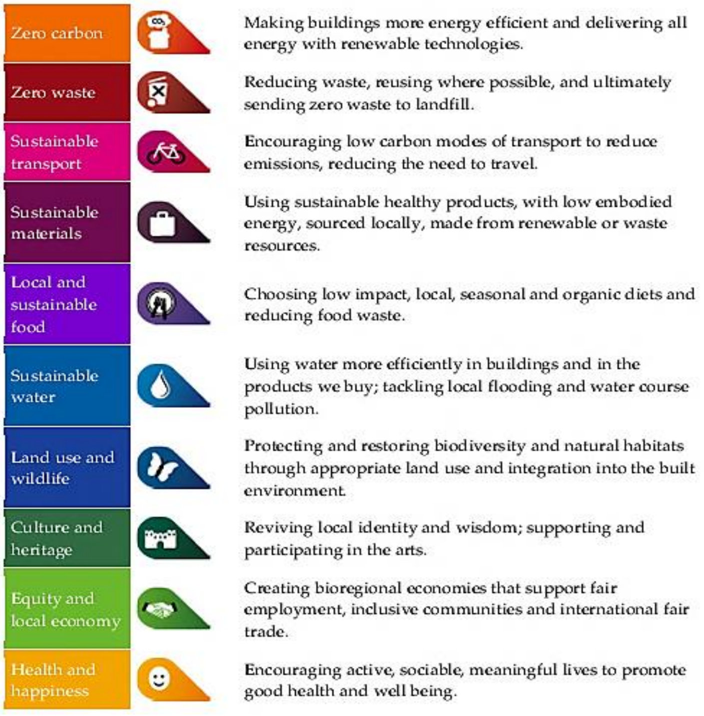


Figure (2.36): Principles of BioRegional One Plant Living framework
Source: (Kyvelou et al., 2012)

- The Eco Town framework by the Cambridge quality charter of growth

From the other side, the Eco-Town framework focuses on state of the art green building, energy, transport technologies and materials to be used in an urban development context. This one is mainly to ensure zero carbon housing and energy efficiencies, which can be achieved through waste reduction, energy conservation technologies and the use of more sustainable sources of energy. The framework consists of four fields, which namely the four Cs: climate, connectivity, community and character. Each one of the four is subdivided in several criteria, as shown in the following figure (2. 37) (Kyvelou et al., 2012).

UK Eco-Towns	
Climate	Energy
	Water
	Environment
	Planning for low carbon
	Low-environmental
Character	Place-making
	New design and High Design Standards
	Attractiveness and desirability
	Investment
	Locally-based facilities
Connectivity	Employment opportunities
	Transport
	Services
Community	Social mix
	Sustainable community principles
	Governance
	Delivery organisation

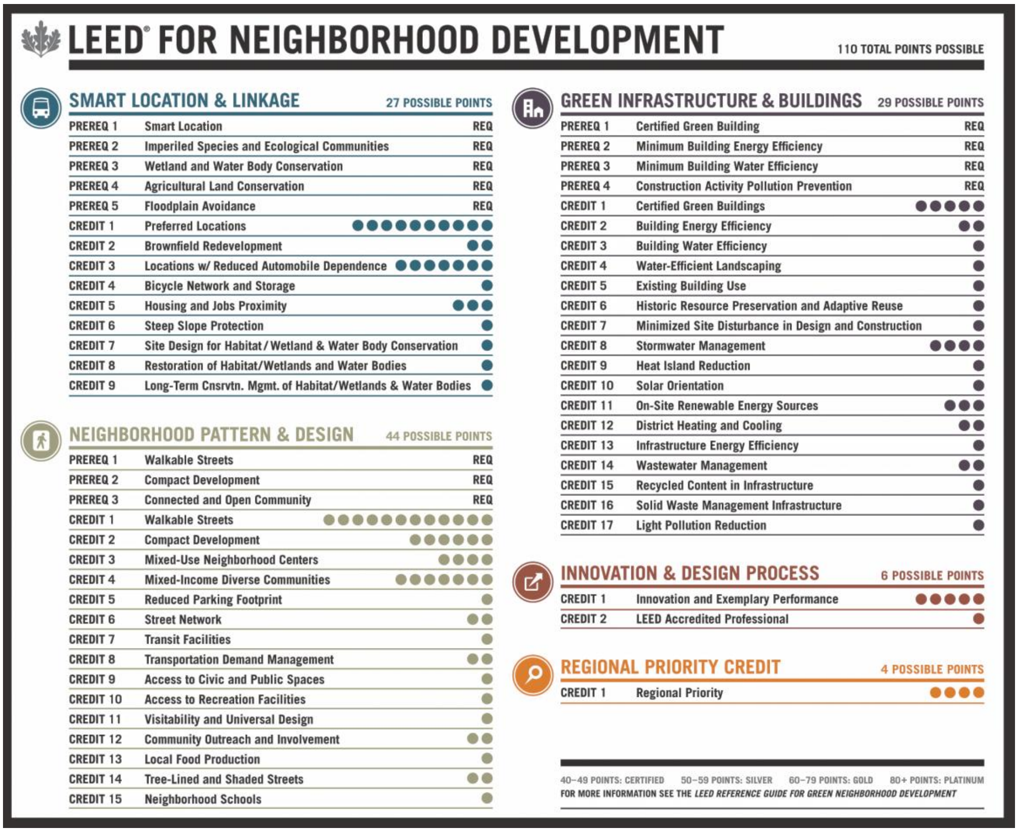
Figure (2.37): Principles of Eco- town framework
Source: (Kyvelou et al., 2012)

- The LEED for Neighborhood Development project scorecard

Another tool is the Leadership in Energy and Environmental Design for Neighborhood Development Rating System. It was stated by Welch et al. (2010) that, the LEED for Neighborhood Development promotes best practices in location, design and development at the neighborhood scale. It is the first LEED rating system to focus beyond the building level and evaluate the whole neighborhoods or multi building projects that contribute to neighborhoods. Add to that, it prioritizes criteria such as site location, urban design, transportation, housing affordability, walkability, socio-economics and neighborhood wide green infrastructure, in addition to the green buildings. In general, the tool is subdivided into five categories, each of them has several analysis criteria which are either prerequisite or are being given a score. The main five categories of this tool are:

- The Smart Location and Linkage.
- Neighborhood pattern and Design.
- Green Infrastructure and Buildings.
- Innovation and Design Process.
- Regional Priority Credit.

This tool is similar to all the other LEED rating systems, which evaluate projects based on a 100-point base scale, including up to 10 bonus points special for the innovation and regional priority, as shown in figure (2.38) (Welch et al., 2010). Projects seeking certification must meet all prerequisites and earn at least 40 points by achieving various credits. Beyond basic certification, projects may achieve Silver (50 points), Gold (60 points), or Platinum (80+ points) certification for increasingly high performance, as shown in figure (2.39) (United States Green building council, 2014).



LEED® FOR NEIGHBORHOOD DEVELOPMENT — 110 TOTAL POINTS POSSIBLE

SMART LOCATION & LINKAGE		27 POSSIBLE POINTS
PREREQ 1	Smart Location	REQ
PREREQ 2	Imperiled Species and Ecological Communities	REQ
PREREQ 3	Wetland and Water Body Conservation	REQ
PREREQ 4	Agricultural Land Conservation	REQ
PREREQ 5	Floodplain Avoidance	REQ
CREDIT 1	Preferred Locations	●●●●●●●●●●
CREDIT 2	Brownfield Redevelopment	●●
CREDIT 3	Locations w/ Reduced Automobile Dependence	●●●●●●●
CREDIT 4	Bicycle Network and Storage	●
CREDIT 5	Housing and Jobs Proximity	●●●
CREDIT 6	Steep Slope Protection	●
CREDIT 7	Site Design for Habitat / Wetland & Water Body Conservation	●
CREDIT 8	Restoration of Habitat/Wetlands and Water Bodies	●
CREDIT 9	Long-Term Cnsrvtn. Mgmt. of Habitat/Wetlands & Water Bodies	●

NEIGHBORHOOD PATTERN & DESIGN		44 POSSIBLE POINTS
PREREQ 1	Walkable Streets	REQ
PREREQ 2	Compact Development	REQ
PREREQ 3	Connected and Open Community	REQ
CREDIT 1	Walkable Streets	●●●●●●●●●●●●
CREDIT 2	Compact Development	●●●●●●
CREDIT 3	Mixed-Use Neighborhood Centers	●●●●
CREDIT 4	Mixed-Income Diverse Communities	●●●●●●●
CREDIT 5	Reduced Parking Footprint	●
CREDIT 6	Street Network	●●
CREDIT 7	Transit Facilities	●
CREDIT 8	Transportation Demand Management	●●
CREDIT 9	Access to Civic and Public Spaces	●
CREDIT 10	Access to Recreation Facilities	●
CREDIT 11	Visitability and Universal Design	●
CREDIT 12	Community Outreach and Involvement	●●
CREDIT 13	Local Food Production	●
CREDIT 14	Tree-Lined and Shaded Streets	●●
CREDIT 15	Neighborhood Schools	●

GREEN INFRASTRUCTURE & BUILDINGS		29 POSSIBLE POINTS
PREREQ 1	Certified Green Building	REQ
PREREQ 2	Minimum Building Energy Efficiency	REQ
PREREQ 3	Minimum Building Water Efficiency	REQ
PREREQ 4	Construction Activity Pollution Prevention	REQ
CREDIT 1	Certified Green Buildings	●●●●●
CREDIT 2	Building Energy Efficiency	●●
CREDIT 3	Building Water Efficiency	●
CREDIT 4	Water-Efficient Landscaping	●
CREDIT 5	Existing Building Use	●
CREDIT 6	Historic Resource Preservation and Adaptive Reuse	●
CREDIT 7	Minimized Site Disturbance in Design and Construction	●
CREDIT 8	Stormwater Management	●●●●
CREDIT 9	Heat Island Reduction	●
CREDIT 10	Solar Orientation	●
CREDIT 11	On-Site Renewable Energy Sources	●●●
CREDIT 12	District Heating and Cooling	●●
CREDIT 13	Infrastructure Energy Efficiency	●
CREDIT 14	Wastewater Management	●●
CREDIT 15	Recycled Content in Infrastructure	●
CREDIT 16	Solid Waste Management Infrastructure	●
CREDIT 17	Light Pollution Reduction	●

INNOVATION & DESIGN PROCESS		6 POSSIBLE POINTS
CREDIT 1	Innovation and Exemplary Performance	●●●●●
CREDIT 2	LEED Accredited Professional	●

REGIONAL PRIORITY CREDIT		4 POSSIBLE POINTS
CREDIT 1	Regional Priority	●●●●

40–49 POINTS: CERTIFIED   50–59 POINTS: SILVER   60–79 POINTS: GOLD   80+ POINTS: PLATINUM
FOR MORE INFORMATION SEE THE *LEED REFERENCE GUIDE FOR GREEN NEIGHBORHOOD DEVELOPMENT*

Figure (2.38): Principles of LEED certification
Source :(United States Green building council, 2014)

Figure (2.39): LEED Certification levels
Source :(United States Green building council, 2014)

For all LEED rating systems except LEED-ND, certification occurs after a project is fully constructed. While in LEED-ND a three-stage certification process has been developed, this is due to the long time frame of large scale planning and development projects (Welch et al., 2010). The first stage is the conditional approval of a LEED-ND plan, this stage is optional for the projects in their initial planning phase. While the second one is pre-certified LEED-ND plan, this stage is available for projects that are approved and fully entitled to be built, but that have not yet completed construction. The last stage is LEED-ND Certified Neighborhood, as at this stage certification is finalized and available for projects that are completed and ready to be occupied. Those the three steps allow the projects to be recognized as they move through the planning, entitlement and construction process, as well as to receive feedback throughout the project development process (United States Green building council, 2014).

On the other hand, there is a lot of rating systems around the world have been developed since 1980 to objectively mitigate the impact of buildings on the natural environment and evaluate energy performance that spans the broad spectrum of sustainability (Welch et al., 2010). It's worth mentioning that, the green building rating tools can assist in addressing the climate change issues facing cities today, by encouraging the development of more efficient buildings (United States Green building council, 2014). This argument is based on the large environmental footprint of buildings, especially when considering the high reliance on the air conditioning and heating systems (Hoffman, 2008).

Thus, many countries have introduced new rating tools over the past few years in order to improve the knowledge about the level of sustainability in each country’s building stock (Welch et al., 2010). According to the study done by Reed et al. (2009), which investigated the international sustainability tools to examine their characteristics and differences, concluded that there are different tools could be directly compared with each other and can be used all over the world, as shown in figure (2.40). Among those tools are LEED certification, NABERS which is the National Australian Built Environment Rating System. In addition to the Green Star in Australia, BREEAM in UK, HQE in France, as well as DGNB in Germany.

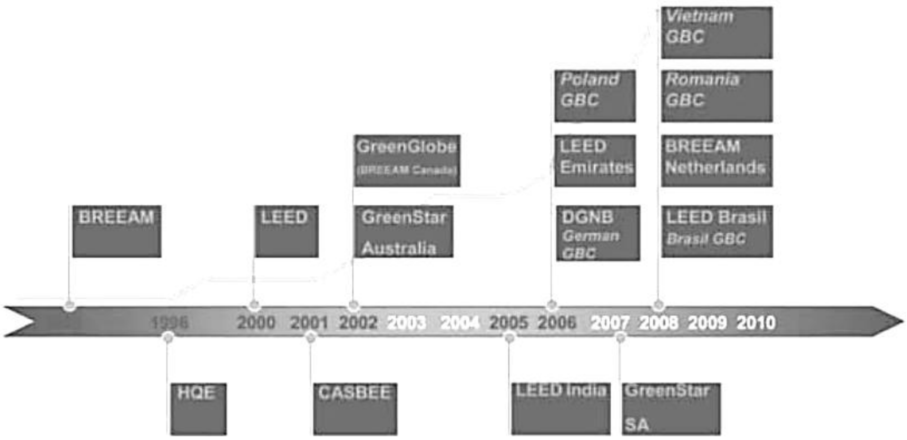


Figure (2.40): Timeline of the development rating tools in different countries
Source: (Reed et al., 2009)

The following part provides some clarification of some of those assessment tools for sustainable buildings, such as:

- <u>BREEAM (Building Research Establishment Environmental Assessment Method):</u>

It was launched by the Building Research Establishment to provide a means to evaluate the environmental performance of buildings. It's worth mentioning that, BREEAM assesses the overall performance of buildings against a range of environmental issues and awards credits where the building achieves a benchmark performance for each issue, as shown in figure (2.41) (Reed et al., 2009). The process then uses a set of environmental weightings to enable the credits to be added together to produce a single overall score of Excellent, Very Good, Good or Pass. The assessments are carried out for six building sectors such as domestic, health, industrial, commercial, retail and education buildings (Building Research Establishment (BRE) Global, 2013).

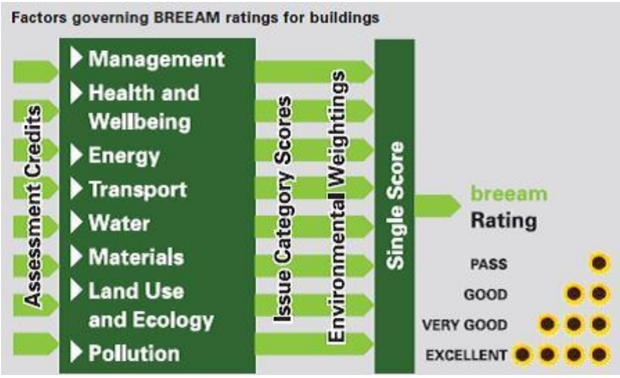


Figure (2.41): Factors governing BREEAM ratings for the building
Source: (Building Research Establishment (BRE) Global, 2013)

- DGNB (Deutsche Gessellschaft fur Nachhaltiges Bauen):

The DGNB (Deutsche Gessellschaft fur Nachhaltiges Bauen) certification system started to appear in 2007 by the German Sustainable Building Council. The DGNB focuses on sustainable, environmentally friendly and economically efficient buildings (Reed et al., 2009). As the other systems described before, the DGNB covers all the relevant issues of sustainable construction, the main objective of it is to develop and promote contents, ways and solutions for the planning, construction and operation process of buildings to meet the criteria of sustainability. It is organized around six fields, such as: ecological quality, economical quality, sociocultural and functional quality, technical quality, process quality, as well as location quality, as shown in figure (2.42). On the other side, the label is rewarded in the three categories of Bronze, Silver and Gold (German Sustainable Building Council (GeSBC), 2014).

Figure (2.42): Factors governing DGNB ratings for the buildings
Source: (German Sustainable Building Council (GeSBC), 2014)

It is also worth mentioning that, nowadays this rating system focuses on sustainability assessment only for office and administration buildings. While the other assessments carried out for the other building sectors such as retail, industrial, education buildings, as well as the assessments for the urban development or district are still under development phase, as shown in figure (2.43) (German Sustainable Building Council (GeSBC), 2014).

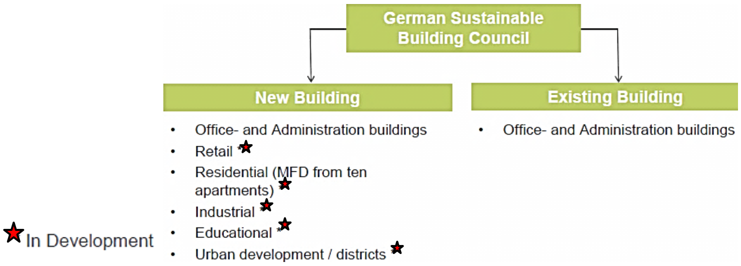


Figure (2.43): System models of DGNB
Source: (German Sustainable Building Council (GeSBC), 2014)

To sum up, it is quite important to define the ways used to choose the most appropriate sustainability assessment tool. As Kyvelou et al. (2012) conclude that it is not easy to select the most appropriate tool, this is because none of them addressing all the issues and remaining at the same time easy to use. It was shown that most of the environmental, social and economic parameters are being implemented in different ways for each project. As a good example, the figure (2.44) shows a comparison between different certification systems which are the LEED, BREEAM and DGNB for new office building (German Sustainable Building Council (GeSBC), 2014). The result shows that, the aspect of the good design is different from one system to another. Also, it is not only related to environmental design, but also to other issues such as social aspects and technical aspects. In general, sustainability assessment tools contain several assumptions about what is important to be measured, how to measure it, what role needs to be considered in the assessment and how sustainability perspectives are both relevant and legitimate (Gasparatos & Scolobig, 2012).

Buildings and uses	DGNB	LEED	BREEAM
Ecological aspects	22,5%	64,0%	58,5%
Economic aspects	22,5%	0,0%	0,0%
Social aspects	16,0%	14,5%	14,0%
Functional aspects	6,5%	0,5%	5,0%
Technical aspects	22,5%	0,0%	5,0%
Aspects in planning processes	5,0%	2,0%	1,0%
Aspects in construction processes	3,0%	8,0%	7,0%
Aspects in operational processes	2,0%	1,5%	4,0%
Aspects of the building site	Separately evaluated	9,5%	5,5%

Legend
Proportion of elements considered in category > 31%
Proportion of elements considered in category 11% < 31%
Proportion of elements considered in category < 10%
Category not considered

Figure (2.44): comparison between BREEAM, LEED and DGNB for new office building
Source: (German Sustainable Building Council (GeSBC), 2014)

2.9.3. <u>Difference between Indicators and Assessment Tools:</u>

To sum up, the study done by Yigitcanlar & Dur (2010) mentioned the differences between the indicators and the assessment tools. It concluded them into the following points:

- The main difference that the sustainability indicators based on the global scale, such as based on countries, on cities and few of them can be used to assess the sustainability of firm and organizations. This is because most of the indicators are used to help in developing the policies to effectively integrate the concerns on environmental protection, economic equity and social well-being in it, in order to support any urban development plans. While the assessment tools are used to assess the sustainability of buildings, neighborhoods and organizations, example of them is the LEED NB and LEED New Construction. They have fewer impacts on developing the policies as they do not take into account all of the environmental, economic and social aspects. They only help to determine the level of any city and the way it should go through.

- Most indicators based approaches only on highlighting issues and do not provide the answer of the question which is why the level of sustainability differs from one place to another. In other words, in most of these approaches, the link between theory and practice has not been well established. Therefore, it is important that key indicators need to be supplemented by qualitative and quantitative information on impact and performance levels. From the other side the assessment tools also do not give the solution, it only gives alerts to different problems before they get worse in order to avoid them early. But the best assessment tool should show where the problem areas exactly.
- From the local perspective and the regional scales, sustainability indicators reflect the large scale environmental and economic considerations, as well as local social issues relevant to urban sustainability. While only a few of the assessment tools have integral approaches that take into account all of the environmental, economic and social aspects, as in most cases the focus is on one of the three aspects. Also, although each point in the assessment tool is supposed to cover all of the paths of sustainability, there are parameters are always neglected in many of them.

2.10. Conclusion:

The results of this chapter show that, rising environmental concerns and problems have put sustainable urban development on the top of the agenda in almost every city across the world. In order to define this sustainable development, many concepts and definitions have been presented, the most suitable definition is the one which achieves the proper use of resources, protection of the natural environment, least possible use of non-renewable resources and satisfaction of basic human needs. Results also conclude that, the goal of sustainable urban development is to make balance between four aspects, economic, environmental and social, thus in order to reach livable, productive and inclusive cities, towns and neighborhood.

On the other side, to sum up it can be said that planning for sustainable urban, has started with designing the neighborhood, which has a key role in promoting future urban sustainability and also responded to global changes in the world. Results show that, the term sustainable neighborhoods not only low in poverty and low in crime, but also walkable, transit served and access to a wide variety of services and facilities. According to that, the sustainability measures of the neighborhoods can be condensed into nine areas, as shown in figure (2.45). All of which improve the ability of the place to sustain itself in the long term. From another perspective, certain policies should be applied, also good monitoring systems should be used in order to evaluate the sustainability themes within the neighborhoods. This means that, each government should choose its own indicators or its own sustainability assessment tools to monitor and support their policies. Moreover, it's worthwhile to mention that, in the next chapter the concentration will be done on the energy efficiency term. This may be returned to the importance of the energy which represents as a key factor in the development of the countries, enabling their economic growth and shaping their environments to the needs of human society. Hence, in the next chapter the research tried to simplify the linkages between energy efficiency and residential areas, thus in order to find innovative concepts in a safe, sustainable and the economic energy system in the future.

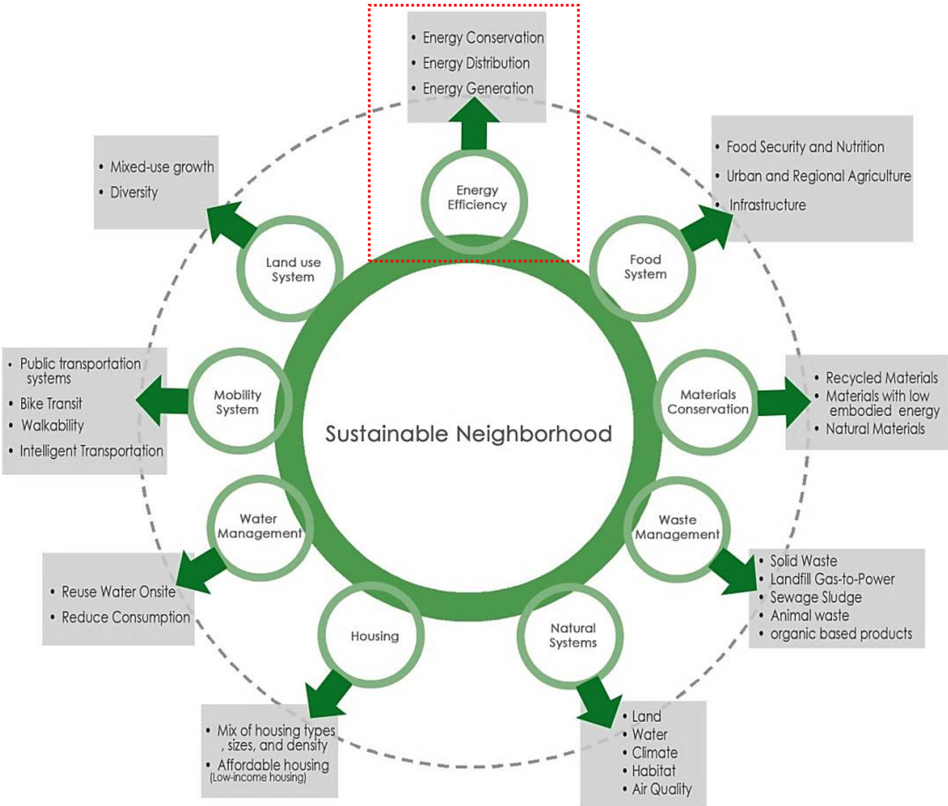


Figure (2.45): The sustainability measures of neighborhood
Source: adapted by the author

3. Chapter Three: Energy Efficiency

3.1. Introduction:

This chapter focused on the essential role that energy sector can play as a tool for assessing progress towards sustainable development. In this chapter the research tried to simplify the linkages between energy efficiency and residential areas. It reviewed the literature about ' Energy Efficiency', in order to outline the principles of configuration that are necessary to fulfill energy future requirements in the residential built environment. The chapter started with providing a brief explanation of the environmental problems by concentrating on two of the most challenging ones, which are the energy crisis and the climate change. Then, it explored the concept of the 'Sustainable Energy Plan ' and the methodology behind its elaboration with focus on its design principles and the challenges it faces. This plan started with the justification of the potential role of energy consumption on two scales as a level of action. The first one is the urban scale, which discusses the main design principles for energy efficient urban configurations. While the second is the architectural scale, which discusses the design principles required for achieving an energy efficient house. The next step in the plan was exploring the concept of energy distribution by focusing on the smart grid and smart building techniques. Then, key issues related to energy generation are investigated, with focus on the powerful role they can play in decreasing the dependence on unrenewable resources. Additionally, some examples of the standard energy codes all over the world are then discussed, with an explanation of the differences between rating systems and energy codes. The main conclusion of this chapter is to set out the energy efficiency checklist which included the design principles that are necessary to achieve energy efficiency while designing any residential area.

3.2. Environmental Problems:

As mentioned before, there are various forms of environmental problems already faced societies. Much work has been carried out by various organizations and institutions to study the wasteful consumption of the world’s resources, that to find ways to reduce the rate of the consumption. As, it was mentioned in the Masdar Carbon Report in (2011) that, the planet’s resources are being used faster than they can be renewed, that lead to increase the humanity’s Ecological Footprint. The report also concluded that, the biggest contributor to this humanity’s footprint is the way in which the energy can be generated and used. As much the use of such energy sources increase, the amount of carbon dioxide increases. From another side, the more carbon dioxide and other greenhouse gases emitted into the earth's atmosphere, the more heat is trapped within the atmosphere. All of that, lead to a wasteful increase in the global warming that causes climate change and serious environmental problems. Thus, to sum up, it can be said that the governments around the world should focus on achieving low-carbon economies, which powered by a secure mix of clean and sustainable energy sources. Accordingly, the following part discusses in details the most serious present-day and future problems not only in Egypt, but also for the whole regions, which are considered to be the energy crisis and the climate change:

- **Climate Change:**

In the term of the climate change, it could be summed up that; it represents the shift in long-term global weather patterns due to human actions and activities. Actually, it's not exclusive to warming or cooling (Answers, 2013). The problem is that the burning of fossil fuels for buildings, transportation, power plants, industrial livestock farming, as well as deforestation, are resulting in too much greenhouse gas accumulating in the atmosphere. As a result, sunlight enters the atmosphere, but the gases build-up cannot escape into the space, resulting in a hotter atmosphere. This in turn causes increasingly significant problems such as extreme weather, changes in rainfall patterns, rising in the sea level, flooding and probable destruction of the ecosystems. All of that increase the spread of diseases affecting human health and affecting the living environment of human beings (A Mubadala Company, 2010).

From another side, it is quite important to define the Greenhouse gases. A study done by Allen & McKeever (1996) reported that, this term represents the gases present in the atmosphere which reduce the loss of heat into space and therefore contribute to global temperatures. Greenhouse gases are essential to maintaining the temperature of the earth, without them the planet would be so cold and it would be uninhabitable, as shown in figure (3.1)

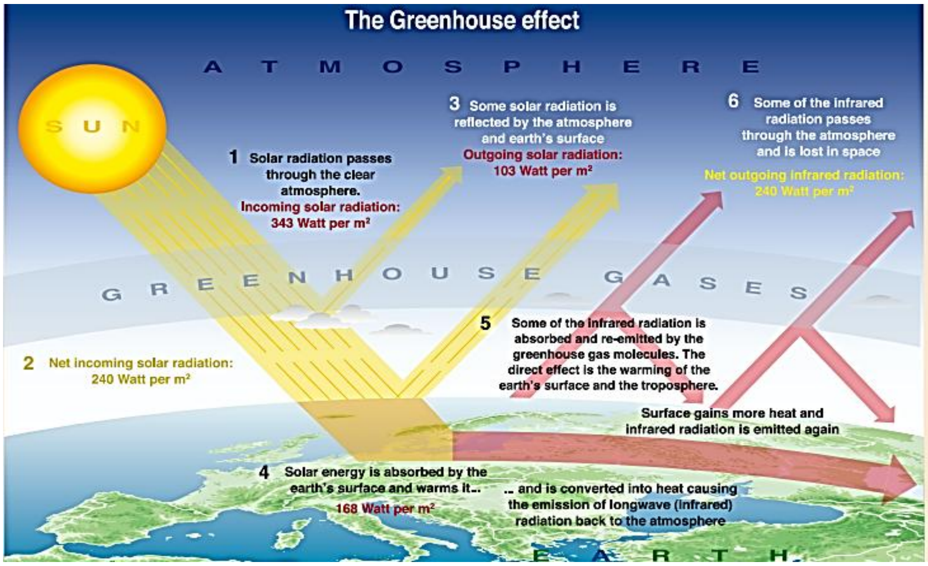


Figure (3.1): The Greenhouse effect
Source: (Thomas, 2003)

- **<u>Energy crisis:</u>**

The second major event threatening the planet is the escalating consumption of energy and the resulting depletion of fossil fuel resources. Many experts believe that, the world is using fossil fuels at a non-regenerative rate. So it can be said that, many countries have already faced the problem of running out of fossil fuel resources. It is also worth mentioning that, all energy consumption curves are still trending up, although the world has already reached its peak for oil extraction and production. As, it has been reported that, it is only a matter of time before all the non-renewable toxic sources, especially oil and coal vanish, as shown in figure (3.2). This means that, there is a significant gap between the current trends in urban development and the desired sustainable energy future (The Environmental Literacy Council, 2013).

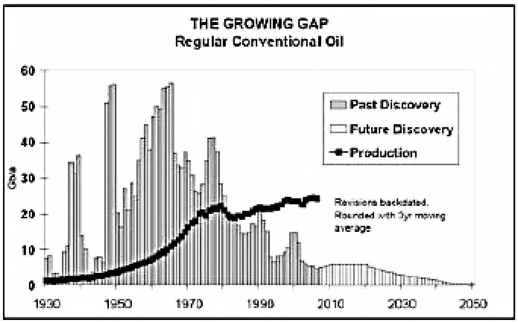


Figure (3.2): Inverse relation between rate of oil discovery and production
Source: (ASPO Ireland Newsletter, 2007)

From another perspective, another study done by Masdar Carbon (2011) demonstrated that, the world is at the dawn of a global energy revolution that will transform the way of thinking about power generation, distribution and consumption. Actually, the future of cities is limited because there is no longer enough energy to run them. Thus, it becomes a fact that all the cities around the world should combine an integrated urban planning process with a big shift in designing their cities. They should depend mainly on increasing energy efficiency with very low energy uses, high levels of renewable and decentralized energy supply.

In short, it can be said that it is an almost a fact, that the climate change and energy issues are major sources of concern for the future. Those two problems will probably lead to social, political and economic disturbances. Subsequently, the actions should be taken now to avoid possible serious environmental damages. This means that, the local authorities must change the way they develop their plans. Also more solutions, more government support and concerted efforts must be taken to reduce the volume of greenhouse gases (GHG) released into the atmosphere. This principally means finding ways to apply sustainable energy plans which are the fundamental prerequisites for the sustainable development of the world and of the megacities in particular.

3.3. Importance of Sustainable Energy Plan:

As mentioned before, it is quite important to say that the energy sector and carbon mitigation have to be at the center of any sustainable development strategy. According to the UN-HABITAT and UNEP Report in (2009), the use of energy, the types of energy used and the lack of access to sufficient energy have far reaching implications for a city's economic development, its environmental health and its social development. Among the various approaches and strategies to enhance energy action plan, the study concentrated on the principles of the sustainable energy planning for the developing countries. It has been mentioned that, their urban centers should engage their development with a sustainable energy plan. This plan can be achieved through technology and behavior changes to improve efficiency and by closing the energy loop in production. It is also based on solving the problem concerns of the economy, the environment and society. Subsequently, cities in those developing countries will embrace a future where economic and population growth are delinked with the energy consumption. From the other side, energy is consumed in a manner that promotes social cohesion. Add to that, the report also indicated that sustainable energy plan must be at the beginning in any sustainable neighborhood plan. As neighborhoods which implement those plans will reduce their vulnerability to energy scarcity and the energy price rises. They also have less traffic congestion and lower energy input costs. Besides, they have cleaner air with their low-carbon economies, which can afford them a competitive economic edge globally.

In this research, the focus will be only on the environmental aspect, as this aspect requires very different approaches. It's about a whole system which must work together to achieve the best performance. First of all, it must first put the energy service needs of the users and the city. Then finding clean sources for the energy which do not pollute the environment. Then find good ways to deliver the energy to the user in an efficient way, which effectively reduce the energy losses. This will allow rapid development and implementation of the principles which assist the architects and planners in achieving not only sustainable energy action plan, but also overall sustainability.

Thus, this chapter explains the sustainable energy plan which depends mainly on three directions, as shown in figure (3.3).

Firstly, Energy Consumption:

Neighbourhoods are often the large consumers of energy in buildings and public facilities. Efficient energy use is needed first to reduce energy consumption overall before jumping to the renewable sources. So the buildings and urban areas there will minimise their energy needs by complying with the passive standard

Secondly, Energy Distribution:

Neighbourhoods can promote efficient energy use, through efficient management of the distribution of energy. As the distribution of energy from the grid to the building or site will inevitably lead to some losses. So shifting to deliver energy in efficient way will help to reach energy efficiency plan

Thirdly, Energy Generation:

In the term of the energy generation, the developing countries don't need to repeat the mistakes of the highly industrialised countries which depended on creating an energy infrastructure based on fossil fuels. But they actually need to jump directly to renewable energy sources and more efficient technologies, in which the balance of energy demand will be meet by either on-site renewable energy generation or off-site. In general, the solar energy,wind energy, biogas and geothermal can be used to produce heat & electricity

Figure (3.3): Sustainable energy plan hierarchy
Source: (UN-HABITAT & UNEP, 2009) adapted by the author

3.4. Energy Consumption: Techniques of Energy Conservation:

As mentioned before, reducing energy consumption at both scales of urban and architecture will minimize the greenhouse gas emissions, improve health and decrease the energy crisis. Regarding residential projects, they consume around 22% of the energy, which is accounted for 39% of all greenhouse gas (GHG) emissions, as shown in figure (3.4) (Hoffman, 2008). Thus, if the energy conservation in the residential buildings decreased, that helps in carrying out sustainable stratagem and reducing greenhouse. According to that, this research focuses on residential areas on the neighborhood scale.

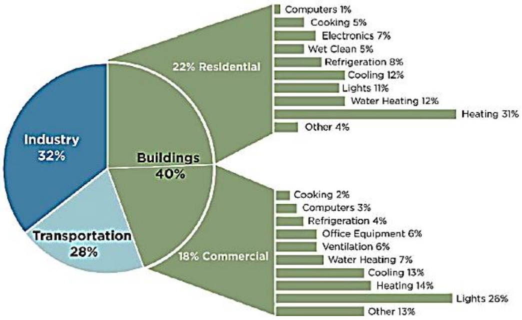


Figure (3.4): Primary energy consumption in building
Source: (Ebert & Baumann Consulting Engineers, 2009)

From an another perspective, the study done by Tereci et al. (2010) indicated that, the decisions related to use less energy, will be applied either by using more efficient technologies or using the site conditions at the earliest stage of the design. Those decisions depend mainly on adopting strategies such as orientation, massing, window positioning, building envelope design, in which they have low initial costs and provides long-term savings in the energy performance, as shown in figure (3.5). Accordingly, this part relates to all elements and systems of the buildings that could contribute to a better energy efficiency and sustainability through the predesign and conceptual design phases, but it is worth mentioning that the other phases are also important to be considered in order to achieve the best performance, as shown in table (3.1).

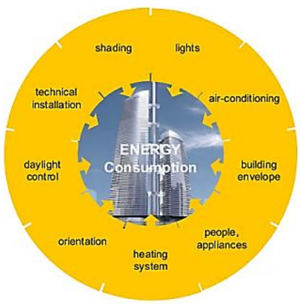


Figure (3.5): Influences of energy conservation
Source: (Ebert & Baumann Consulting Engineers, 2009)

Stage	Parameters	Description
1.Predesign	Target	The first step is to understand requirements for the project and the existing site conditions and context, understanding how the space will be used, reading applicable codes and laws.
	Activities	Understanding the potential and limitations of passive design strategies to meet the goals of thermal and visual comfort. Also understanding the opportunities for renewable energy and exploring the role of material selection.
2.Conceptual Design	Target	At this stage when the building geometry is still evolving, it's important to take advantage of the site's available sun and wind for passive design strategies. Early energy modelling can help define building orientation, massing, program layout, window size, façade shading and envelope materials.
	Activities	As a result of these iterations, the designer will understand which parameters drive the performance of the design and he will start to refine the overall form, materiality and functional layout of the building.
3. Design Development	Target	During this phase the designer will begin problem solving and studying the details of alternate design concepts chosen in the conceptual design stage.
	Activities	The designer will work out the passive design details, optimizing each space as appropriate to take advantage of such things as natural ventilation and daylighting. By quantifying thermal and visual comfort.
4. Detailed Design & Documentation	Target	Once the final design is aligned upon, the team will prepare for construction by creating a fully articulated design and building information model.
	Activities	During this phase, the design is articulated well enough to be built and that the systems are properly integrated for maximum performance that meets the energy model requirements.
5. Construction	Target	With the design fully worked-out by the engineers and architects, the designer will now ensure that the construction team can efficiently build the project to the design and performance specifications.
	Activities	The team will fully detail drawings with all of the constructions, connections and systems so that it can be built. The team might also use digital tools to stage, coordinate and visualize the building process.
6. Operations and Maintenance	Target	Once the building has been built (or the retrofit completed), the designer will prepare for occupancy by commissioning the new building. It's also important to provide guidance to help maintain the building over time so that it meets the needs of its occupants.
	Activities	First the designer will test, or commission, the building to ensure that all of the systems are working properly and that the settings match the intentions expressed in the design and energy model. Ongoing monitoring and maintenance is important to ensure the building continues to perform well.

Table (3.1): Projects' progress along fixed major phases
Source: (Autodesk, 2011)adapted by the author

3.4.1. <u>Urban Scale:</u>

The study done by Rosenfeld et al. (1995) emphasized that urban design tools can offer opportunities to reduce energy consumption in residential projects. It can shape communities for efficient energy production, distribution and use. Another study by Fuchs et al. (2008) explained that, the urban design scale can maximize the benefits in terms of energy saving, minimize climate change effects, as well as improve pedestrian comfort. Additionally, some other estimates considered that, there are many levels of actions and design principles to achieve and enhance energy efficiency in the built environment, in which the design should mainly base on the interaction of the building with its surroundings. For other words, neighborhood energy planning should look for energy efficiency configurations at the block and building levels(Allen & McKeever, 1996). Thus, this part aims to focus on the energy efficiency design principles at the scale of urban design. Figure (3.6) shows an abstract diagram depicting the components of urban form and its configurations.

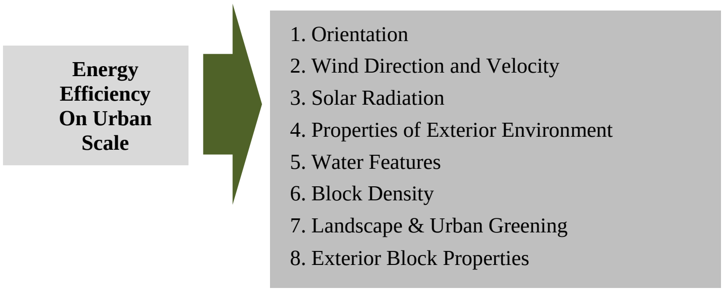


Figure (3.6): The main common principles at the urban scale
Source: Adapted by the author

3.4.1.1. <u>Orientation:</u>

In the term of orientation the project should take the maximum advantages of the site conditions, such as sun, rainwater, prevailing winds, natural features and topography. As it is widely known that, those conditions can influence the energy performance of buildings. They enable the building to minimize energy loads and also maximize the free energy from the sun and wind, in order to reduce GHG emissions that resulting from mechanical heating and cooling (Technology Fact Sheet, 2000). According to Autodesk workshop in (2011), orientation can be the most important step in providing a building with passive thermal and visual comfort. It should be decided together with massing early in the design process. In general, orientation is simply what compass the direction of the building faces; it is measured by the azimuth angle of a surface relative to true north, as shown in figure (3.7).

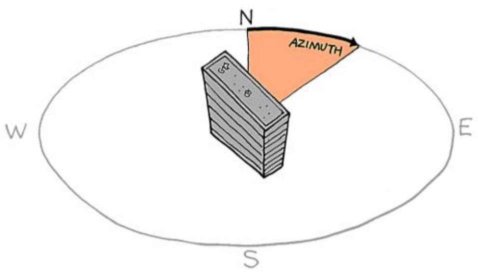


Figure (3.7): The building's orientation is measured by azimuth
Source: (Autodesk, 2011)

- Lots orientation: Lots facing north or south are preferred; this consequently means that the ideal position for the streets is to run east and west, as shown in figure (3.8). It is also widely recognized that, the challenge is to manage the heat gains from the sun and to gain the maximum benefits of the prevailing wind in the site. For this reason, the house should be perpendicular to the prevailing wind, so that the wind could blow onto a large area of the building to go through and cool it (Technology Fact Sheet, 2000).

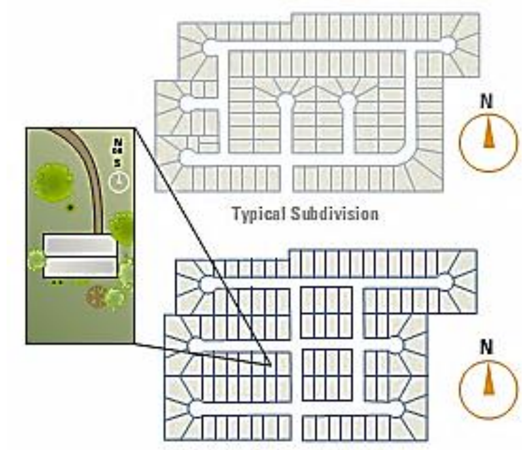


Figure (3.8): Subdivision lot lines and streets
Source :(Technology Fact Sheet, 2000)

- Home Orientation: On the other hand, the study done by Hawks (2005) concluded that, the home should be oriented east-west. This means that, buildings should usually be placed on the site so that its long or main axis runs east-west rather than north-south, as shown in figure (3.9, 3.10, 3.11). This orientation lets consistently to harness daylight and control glare along the long faces of the building. It also lets to minimize glare from the rising or setting sun, in addition to gain the maximum benefits of the site conditions (Autodesk, 2011).

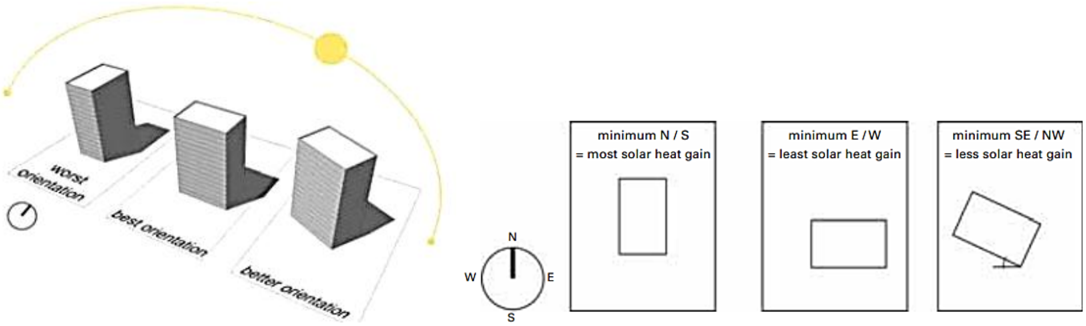


Figure (3.9): Massing and orientation of buildings to prevent exposure to solar gains.
Source: (Green Building Platinum series, 2010)

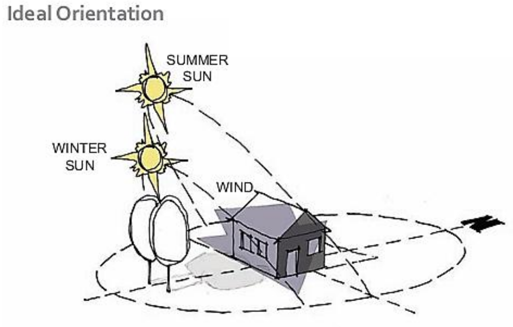


Figure (3.10): The ideal orientation of the house
Source: (Robertson, 2009)

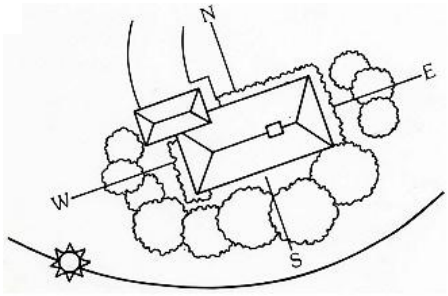


Figure (3.11):The long axis of house should be east- west
Source: (Hawks, 2005)

- Northern and Southern Elevations: The following statement, from Robertson (2009) summed up that, the building should orient the longest elevation towards the south and the majority of window area should be at the north. Add to that, the design should ensure that the unwanted solar gain can be reduced during the warmer months without blocking out the low angled winter sun. Thus, it is quietly recommended to design flexible sunscreens or overhangs for windows on these south facing elevations, as shown in figure (3.12, 3.13).

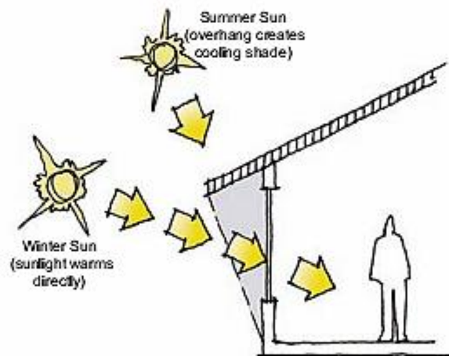


Figure (3.12): The effect of the overhang
Source: (Robertson, 2009)

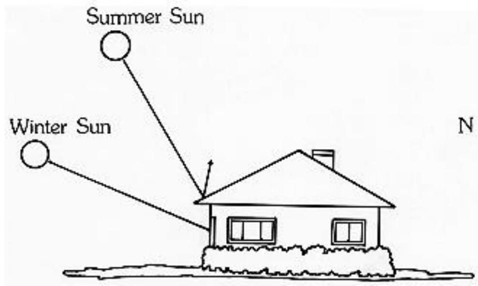


Figure (3.13): Roof overhangs proper depth
Source: (Leona, 2005)

- Eastern and Western Elevations: Besides, it is also important to mention that windows on the east elevation are exposed to solar gain throughout the year. While west-facing windows will provide too much solar gain in the summer and insignificant gains in the winter. For this reason, east- west-facing windows should be limited in size, or avoided unless they can be fully shaded during the summer months. So wherever possible, the house should have any overhang to offer shade from eastern and western summer sun, if it does not have natural features can be used in this case, as shown figure (3.14) (Robertson, 2009).

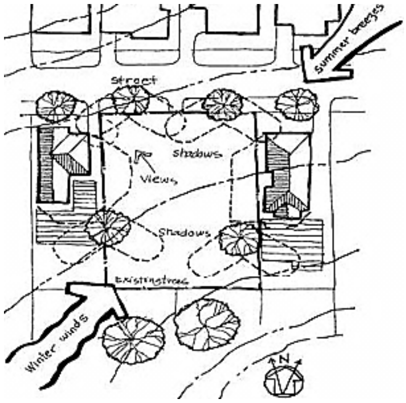


Figure (3.14): Using landscaping elements to offer shade on the building's side
Source: (Building Energy Smart Guide, 1997)

3.4.1.2. Wind Direction and Velocity:

The direction and velocity of the wind affect both indoor and outdoor climates in the built environment. So, wherever possible, the dominant wind directions during the different seasons must be considered in planning houses and neighborhoods. It is stated by Astrand (1996) that, there are various factors which influence the wind direction such as: the orientation of the buildings, their distance from each other and the placement and size of the openings. Accordingly, buildings should be well designed and oriented to maximize benefits from cooling breezes in hot weather and provide shelter from the undesirable winds, as shown in figure (3.15).

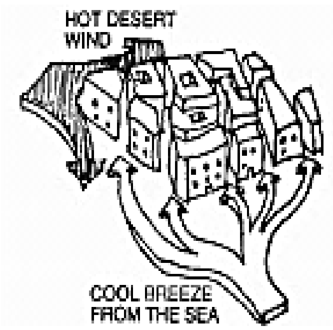


Figure (3.15): The wind direction according to buildings' orientation
Source: (Astrand, 1996)

Some studies and researches showed that, it is quite important to determine the prevailing winds for the site throughout the year. According to the workshop which carried out by Autodesk in (2011) it was observed that, the prevailing wind for the site can be determined by using a "wind rose" diagram, in order to see which wind direction can take advantage of or avoid, as shown in figure (3.16). Another study by Taiao (2008) demonstrated that, the wind rose is a visual representation of the wind conditions at a site generated from historical data. As, it plots the average speeds and the prevailing direction within the site. The study also argued that, the information from the wind rose is then used to find the best orientation of the building to maximize wind ventilation. As it was previously explained that, buildings have to be perpendicular to the prevailing wind to achieve good cross ventilation. Besides, in the buildings that designed around a courtyard, it is preferred to orient the courtyard 45 degrees from the prevailing wind. That in order to maximize wind in the courtyard and cross ventilation through the building (Technology Fact Sheet, 2000).

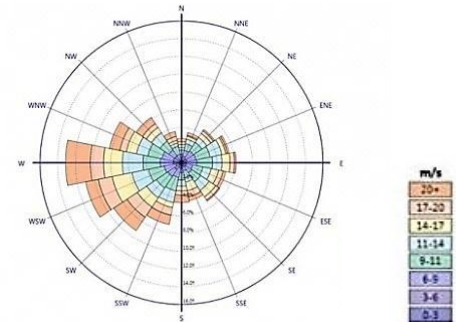


Figure (3.16): Wind rose diagram showing statistics of wind speed and direction throughout the year
Source: (Autodesk, 2011)

In addition to that, the prevailing wind directions listed by weather data may not be the actual prevailing wind directions, as they also depend on the local site obstructions, such as trees or other buildings (Autodesk, 2011). Those obstructions affect wind speed and the amount of heat loss from any adjacent buildings. So wherever possible, any permeable barriers such as a stand of trees should be taken into consideration with its close link with the wind conditions at the site. As it is widely known that, some types of landscape elements can be planted to orient the prevailing wind deep into the buildings, while another can be stand as a barrier for the storms, as shown in figure (3.17) (Donnelly, 2010).

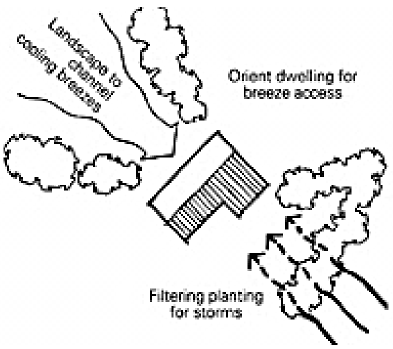


Figure (3.17): Landscape elements with their close link with the wind conditions at the site
Source: (Donnelly, 2010)

As described previously, the ideal situation for the house is being oriented east-west and so has its longest wall facing south, as shown in figure (3.18-3.19). Besides, Donnelly (2010) explained that, the least effective orientation for a building from a thermal efficiency point of view, is when the main walls are at an angle of 45 degrees to the prevailing wind. This is because the wind streams along the length of the wall, thereby cooling it, rather than rising over it, as shown in figure (3.20).

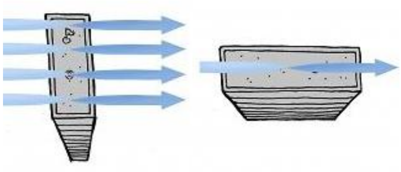


Figure (3.18): The best orientation for maximum passive ventilation
Source: (Donnelly, 2010)

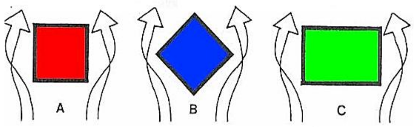


Figure (3.19): Relation between building orientation and wind
Source: (Autodesk, 2011)

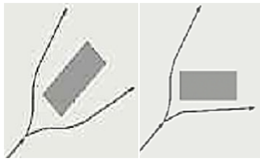


Figure (3.20): Relation between main wall's direction and wind
Source: (Donnelly, 2010)

On the other side, the study also concluded that the locations and distances between the buildings should take into consideration. As those affected the direction of the wind, which help to make outdoor areas breezy, as shown in figure (3.21). Another study demonstrated that, the arrangement of the blocks should be staggered such that the blocks behind are able to receive the wind penetrating through the gaps, as shown in figure (3.22) (Green Building Platinum series, 2010).

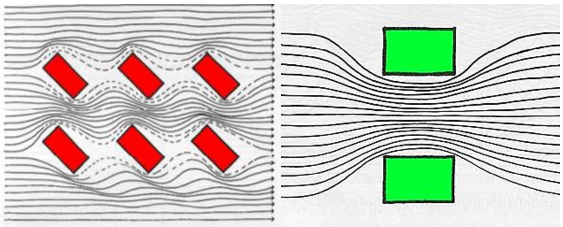


Figure (3.21): Relation between buildings' distances and wind flow
Source: (Donnelly, 2010)

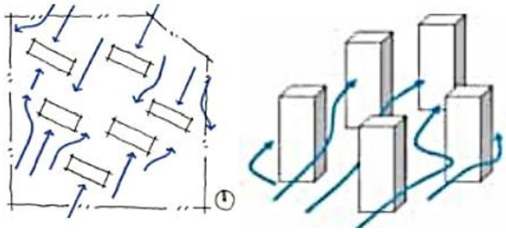


Figure (3.22): Air flow diagram for staggered block
Source: (Green Building Platinum series, 2010)

3.4.1.3. <u>Solar Radiation:</u>

It is widely known that, in hot-arid zones shading is always more desirable than solar access. Thus, it is preferred to use paved areas with shade elements in order to reduce solar radiation gains. Besides, it is also preferred to adjust buildings and tress to each other, in order to provide a large area of shadow as much as possible (Givoni, 1998). This relates very well to the study by El-Deeb et al. (2012) which demonstrated that, shading is more efficient than wall insulation in moderate climates.

In terms of Solar Radiation Metrics, Autodesk workshop (2011) claimed that the metrics for solar radiation is very essential, as it can help in the building's energy analysis. Also, it is quite important to mention that, the intensity of solar radiation is not only important for passive heating, cooling and daylighting, but also for clean energy generation on-site. In general, the intensity of the sun varies by the clarity of the atmosphere and the angle at which the sun strikes the building's surface, this angle is called the "incident angle." From the other hand, the workshop also defined the incident solar radiation values. Those values are given in units of energy per area (W/m^2 or $BTU/hr/ft^2$) and are usually the most valuable metric for early design studies. Furthermore, incident solar radiation values are based on two primary components:

- **Direct radiation** from the sun, which always measured perpendicular to the sun's rays
- **Diffuse radiation,** which always scattered by the clouds, the atmosphere and the ground in front of the surface, this is always measured on a horizontal surface.

Moreover, it is also worth mentioning that, the incident solar radiation values actually calculated and visualized with any analysis software such as Revit, Vasari and Ecotect. The calculation used by the softwares include shading from surrounding objects, the portion of the sky on the surface and the angle of incidence between the sun and the face being analyzed. Thus, to sum up, it can be said that incident solar radiation is just the measure of the amount of sun hitting the surface and it does not depend on material properties (Autodesk, 2011).

From another perspective, the proper design strategies should take in consideration the protection against the high degree of solar radiation. As according to a study by Bodenschatz et al. (2008) which proved that, the denser and compact an urban form in the area, the lower the exposure of spaces between buildings to solar radiation. It has been mentioned by Givoni (1998) that, the denser urban form enables buildings to shade each other and cuts overheating due to solar incidence. But on the other hand, others argued that good designs also must put in consideration the solar access inside the building. As ideally, the glazing on the house should be exposed to sunlight with no obstructions within an arc of 60 degrees on either side of true south, but reasonably good solar access will still be guaranteed if the glazing is unshaded within an arc of 45 degrees (Eley, 1991). The figure (2.29) shows the optimum situation for providing unshaded southern exposure during the winter. But in fact, this is not practical, as all lots are not large enough to accommodate this kind of optimum solar access. Thus, it's recommended to carefully assess shading patterns on smaller lots to make the best compromise. Furthermore, streets that run within east-west orientation are the most preferred, as all lots will either face or back up to south. While streets run north-south are problematic, as shown in figure (3.23) (Eley, 1991).

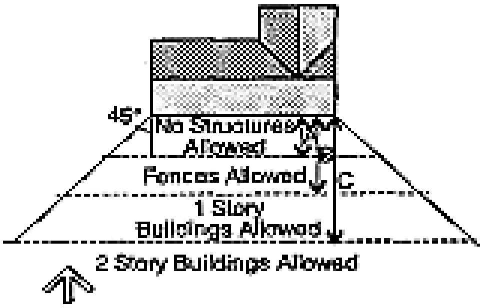


Figure (3.23): Ideal solar access
Source: (Eley, 1991)

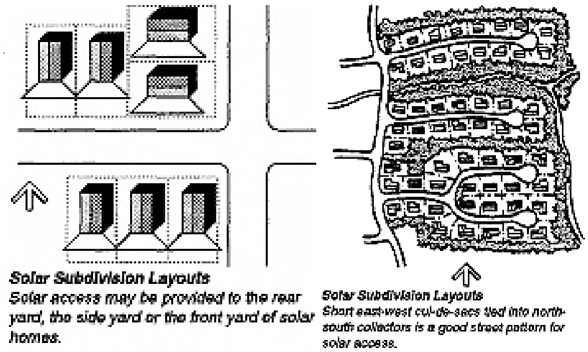
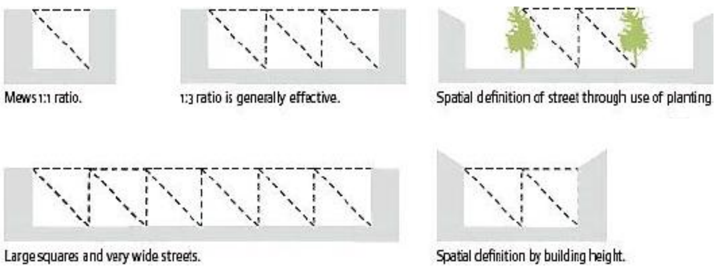


Figure (3.24): Solar subdivision layouts
Source: (Eley, 1991)

In addition to the street orientation, which is considered as a dominant factor to determine the amount of shadow and radiation, there are some basic requirements for the street design, such as the street proportions. Actually, street proportions or street widths have direct impact, in order to reach an efficient solar radiation within neighborhoods. Usually streets proportion defined according to Bodenschatz et al. (2008) by the H/W ratio, when H is the height of the buildings and W is the width of the streets. It was stated by Givoni (1998) that the appropriate width of the streets is a basic tool to shade streets for pedestrians, which in turn encourages walking and protect buildings' façades from the sun' concentration, as shown in figure (3.25). It was agreed that the amount of solar radiation that hits the buildings and reaches the street surfaces, affects the outdoor temperatures, which mainly affect outdoor comfort (El-Deeb et al., 2012). Furthermore, Givoni (1998) demonstrated that, a higher H/W ratio result in lower heating of the urban streets and gives more shades which in sequences support the pedestrian paths. As, the amount of radiation reaching the ground is smaller than in the case of low density. The average ratio of design street sections with a ratio of building height to road corridor width range between 1:6 (low), 1: 3 (medium) and 1:2 (high), as shown in figure (3.26). It is preferred to use the high H/W ratio in a hot climate, in order to encourage walkability.



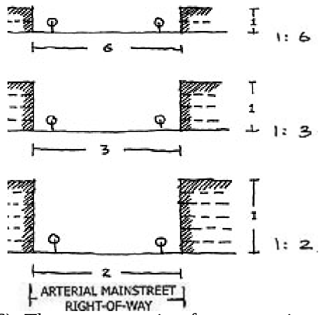


Figure (3.25): H/W ration and Sky view Factor
Source: (Chris Haile, 2012)

Figure (3.26): The average ratio of street sections
Source: (City of Ottawa, 2001)

To sum up, it can be said that, the relationship between buildings and the sun should be taken into consideration. As, the sun's movement through the day and through the year is one of the most crucial environmental factors that should be understood while designing high performance buildings. The building which designed with careful consideration of the sun's path, can take full advantage of energy efficiency and renewable energy strategies, such as natural daylighting, passive heating, PV energy generation and even natural ventilation. However, if the design is not careful, these same opportunities can work in the opposite direction and produce glare or overheating (Autodesk, 2011).

3.4.1.4. <u>Properties of Exterior Environment:</u>

It is worth mentioning, that the specifications of the materials used for the exterior surfaces impact directly on energy consumption within any neighborhood. Furthermore, those urban surfaces are not only limited to the walls, roofs, pavements, sidewalks and exposed surfaces of parking lots, but also any other surfaces which exposed to long hours of sunshine and sun radiation. The proper selection of those surfaces is directly affecting the indoor and outdoor thermal comfort which reduces the energy demand for cooling in the summer (Taha et al., 2001). This proper selection is mainly depends on using high-albedo materials on the exterior urban surface. As, the albedo is one of most significant specifications of any surface, it is actually represented the ratio between the light reflected from a surface and the total light falling upon that surface. Usually the object that has a high-albedo near 1 is very bright; while the object that has a low-albedo near 0 is dark. Surfaces with low-albedo usually become much hotter than high-albedo surfaces. Usage of high-albedo urban surfaces have a direct effect in reducing the heat gain through a building's envelope and also indirect effect by lowering the urban air temperature in the neighborhood of the building (Taha et al., 2001). In short, the following part discussed in details the most three important factors that affecting the exterior surfaces:

- **Paving Materials:**

This strategy contributes to reduce local urban heat build-up, cooling demand and GHG emissions, particularly in urban centers. Thus, it is worthwhile to consider the local feasibility of choosing permeable paving and reflective materials to reduce heat absorption and heat build-up. As, it is obvious that, if the urban surfaces are reflective materials and lighter in color (high-albedo), more of the incoming heat of the sun would be reflected back into space, which lowers temperatures and reduces the heat island effect and this consequently reduces the need for air conditioning (Building Smart Guide, 1997). Nowadays, the asphalt is the dominant material used to pave streets and roads. This traditional asphalt paving absorbs the heat from the sun and re-emits this heat, which in return heats the surrounding air (Taha et al., 2001). Accordingly, it is preferable to use most of the paved surfaces on-site from concrete made with white cement mixtures or light colored pavers instead of traditional asphalt paving, as shown in figure (3.27). In short, it can be said that, it is preferred to use reflective paving materials instead of the impervious absorptive one for sidewalks, driveways, roads and parking lots.

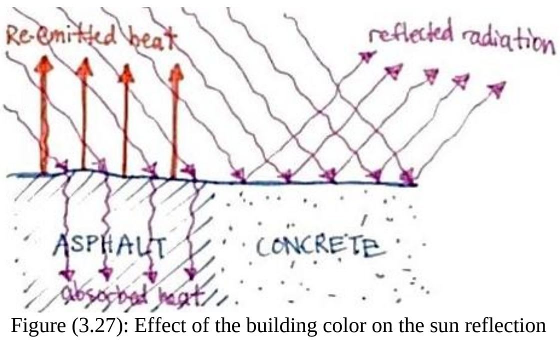


Figure (3.27): Effect of the building color on the sun reflection
Source: (Word Press, 2011)

- **Building Materials:**

On the building scale, selecting its materials should minimize heat penetration through the external skin of the building and maximize thermal mass. Actually, it was proved that, the thicker and denser a material, the greater thermal mass. So, it is worthwhile to consider the design solutions to adjust the thermal mass, that affects the indoor and outdoor thermal comfort which puts loads on the energy needed for cooling in the summer. Thus, double brick construction or other heavyweight materials for walls should be considered. Besides, the building skin should also use materials that help to reflect more sunlight in summer, as shown in figure (3.28). Concrete can be used as an example of materials with high thermal mass, because it is extremely dense and can absorb heat well (Building Smart Guide, 1997).

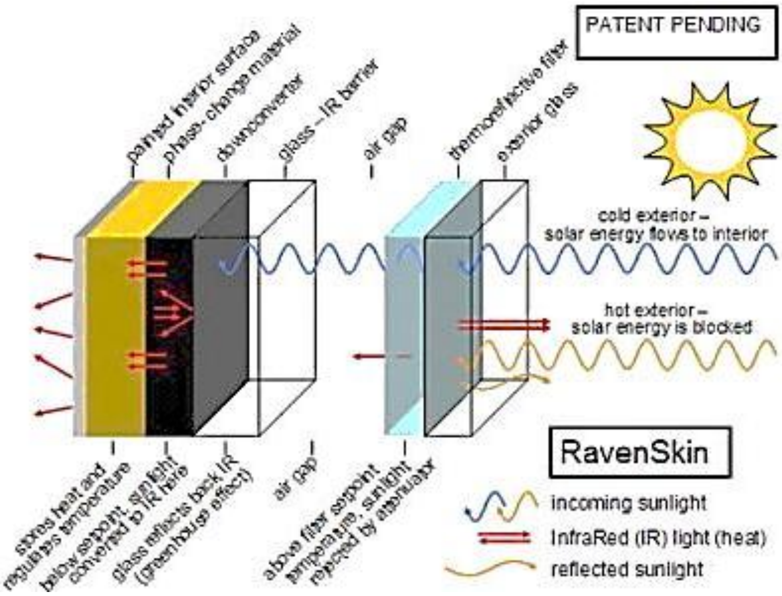


Figure (3.28): Effect of the building skin on the sun reflection
Source: (Quick D. , 2010)

- **<u>Building Colors:</u>**

On the other side, the exterior surface colors such as the color of the roofs and walls can directly affect the space cooling energy demand. Thus, it is worthwhile to consider the color of the material to reduce the absorption of the sun's heat. It was obvious in the study done by Allen & McKeever (1996) that, dark colors (low-albedo) on roofs and walls absorb heat into the building, which then requires additional energy to cool the interior of the building and this directly raises the cooling demand of the building during the summer time. While, the light color (high-albedo) reflect sunlight and helps maintain cooler temperatures within the building and this consequently cut the amount of energy demand. Consequently, in warm climates, it is preferable to use light colored materials and avoid dark paints for external walls and roofs. Figure (3.29,3.30) shows an example of the difference between traditional black rooftops and the white roof.

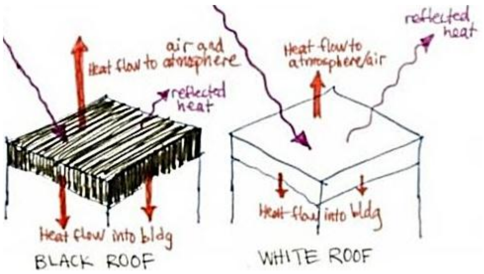


Figure (3.29): Black rooftops versus white roof
Source: (Word Press, 2011)

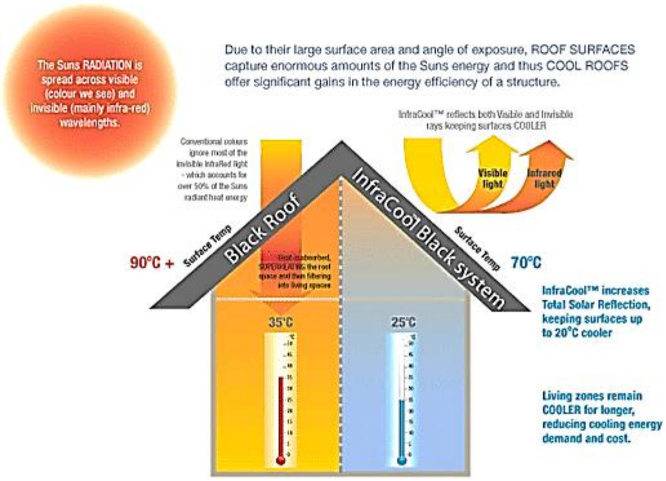


Figure (3.30): Difference between black rooftops and white roof
Source: (Roofline, 2014)

As explained above, that the common measurement of albedo is the ability of the material to reflect sunlight. From another perspective, the measurement most often used for codes and standards is the Solar Reflectance Index (SRI), this is usually used to consider both reflectance and emissivity. SRI is a scale where 0 is the least heat-reflective standard black paint while100 is the most heat-reflective standard white paint. To sum up, it can be said that the "cool roof" can be considered with an SRI above 78 for flat roofs and above 29 for steep roofs (Autodesk, 2011). Table (3.2) shows some other typical values for different materials.

Material surface	**SRI**
Black acrylic paint	0
Typical asphalt	6
“White” asphalt shingle	21
Light gravel-surfaced roof	37
Typical concrete	19 - 52
White acrylic paint	100
Reflective roof membrane	80 - 110

Table (3.2): Show the common Solar Reflectance Indexes
Source: (Autodesk, 2011)

In short, the results show that high-albedo materials can have large impacts on the surface temperature. As discussed by Taha et al. (2001) that, the conventional roofing materials warm up by an average 0.055 degrees C/(W m-2), while the high-albedo surfaces warm up by an average 0.015 degrees C/(W m-2).

3.4.1.5. <u>Water Features:</u>

From an environmental perspective, locating buildings near water bodies such as sprinklers, pools, fountains and lakes can provide evaporative cooling, as they influence the micro climate in moderating variations in ambient temperature. The larger the water bodies, the more micro climatic impact. It's worthwhile to mention that, water bodies take up large amounts of heat in evaporation and causes significant cooling, especially in the hot and dry climate. While in the humid climates, water bodies should be avoided, as it adds to humidity (Majumdar, 2002). As it is widely known that, the evaporation that occurs at the surface of water extracts heat from the air, so the temperature of the air falls and its relative humidity rises, as shown in figure (3.31) (Building Energy Smart Guide, 1997). So, wherever possible, the site should include a reasonable body of water features, in order to increase the cooling potential of a natural ventilation design strategy.

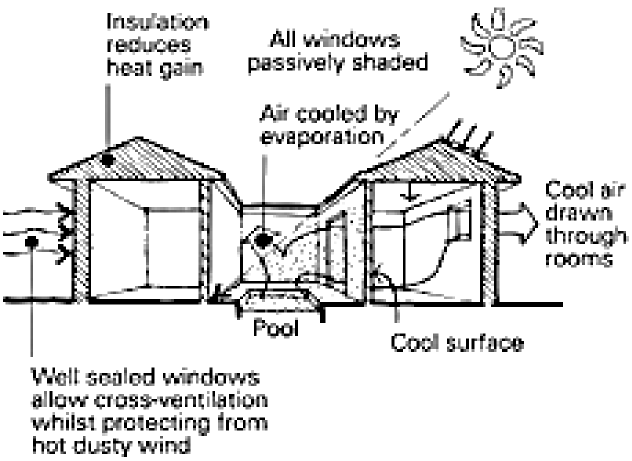


Figure (3.31): Effect of the water bodies inside the court
Source: (TenFoundations.org, 2013)

3.4.1.6. <u>Block Density</u>:

Residential density is one of the factors that, affect GHGs and yet a lot of researches have been conducted on this topic. This review of the literature is intended to determine the preferred average density within residential neighborhoods. The term density is defined as the ratio of building floor space to the site area, it impacts energy consumption as well as the capacity of a building to be passively heated or cooled (Robertson, 2009). It is agreed that, broad planning decisions regarding urban densities are highly correlated to energy consumption configurations. Accordingly, different studies and researches demonstrated that, the lower the density of a city or a district, the higher is the energy consumption. In fact, the low density developments, including single-family houses use nearly twice as much energy per square foot as multi-unit buildings. This may be returned for the reason that, the large single-family buildings have a higher proportion of exterior wall surface, these require more energy for heating or cooling purposes in the buildings. While denser or multi-unit buildings, can take advantage of economies of scale and share heat between walls or floors, thereby reducing overall energy demand. On the other hand, the density can mitigate pressure on municipal infrastructure, including waste, sewer and energy infrastructure. Appropriate use of density can also create efficiencies in the use of this infrastructure and lead to shared benefits of energy usage and common amenities (Fuchs et al., 2008 & Robertson, 2009).

Hence, the study done by Falk & Carley (2012) demonstrated that, creating character requires a minimum net density of 30 units per hectare, as in the garden cities and some of the new towns. Higher densities can support better infrastructure, but also call for high-quality design. It should have a wide choice of housing to create a balanced community over time, as it mainly requires a minimum of between 500 and 1,000 units with homes catering for a range of incomes and ages. In short, the study concluded that, the highly dense built up areas and high population density are better in thermal performance and lower exposure to the solar radiation. In addition to other benefits such as lower land consumption, resource protection and saves commuting time used for daily travel for shopping and work. While low dense built up areas and low population density are responsible for higher exposure to the direct solar radiation. In addition to, other disadvantages such as the loss of farmland, the weakening of the sense of community and rising C02 emissions from local travel.

For that reason, the density standards in any district targeted for sustainable neighborhood development forced the developers to minimize lot sizes in residentially zoned areas. As, without lowering lot sizes in some zoning districts, it would be impossible to achieve increased residential densities as required. To sum up, it can be said that, the target is to reach a district which is protected from solar radiation and reduced the dependence on automobiles, as well as provided shared infrastructure. This may be extended to other features such as the grid pattern of narrower streets, sidewalks, smaller setbacks, front porches, greater protection of green spaces, as well as encourage pedestrian and bicycle travel. One of the best examples which show the high density neighborhood, is Masdar City, as shown in figure (3.32).

Figure (3.32): Masdar City as an example of high density neighborhood
Source: (Trotter, 2008)

3.4.1.7. Landscape & Urban Greening:

The rapid growth of towns and cities led to calls for parks to improve the health of the society. This could be seen as an early precedent to highlight the role of open spaces in supporting what is called sustainable development. Nowadays, green spaces take up more than one-third of total neighborhood areas. Accordingly, these green areas provide a wide range of environmental, economic and social benefits. They have an essential role to play in the structures of the sustainable neighborhood design. As, they are playing a dual role, the first is social that come out of understanding the neighborhood as a community. Meanwhile, the second is the ecological perspective; each of these two approaches covers a different perspective of sustainability applications to the neighborhood scale (Al-Hagla, 2008 & Reid, 2001).

From the ecological perspective, strategic landscaping can reduce home’s energy requirements during all the four seasons. As tress can affect the heating and cooling loads of buildings through blocking out the hot summer sun and encouraging warming solar radiation in winter. On the other hand, they deflect cold winter winds and channel breezes for cooling in spring, summer and fall, as shown in figure (3.33). All of these factors help in improving the air quality and absorbing carbon dioxide, which helps in reducing GHG (Engel-Yan, 2007& Reid, 2001).

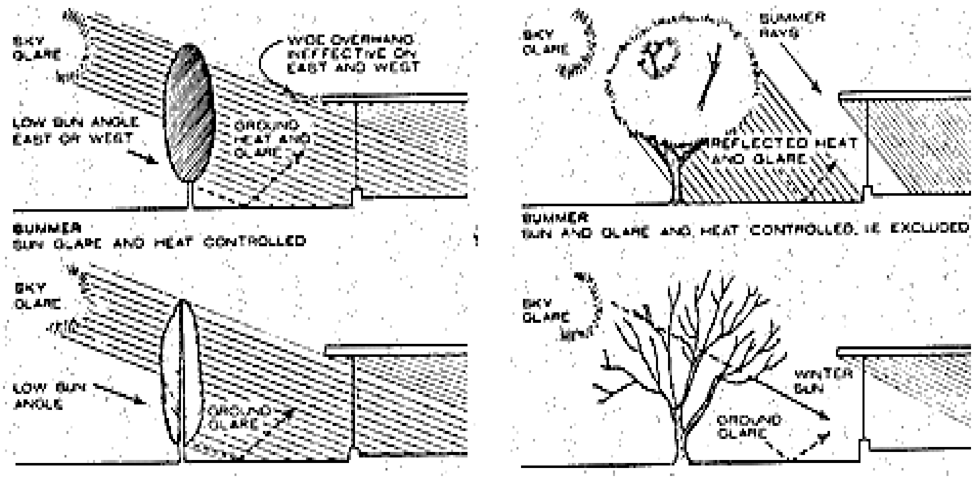


Figure (3.33) Different type of tree planting in different seasons
Source: (Engel-Yan, 2007)

In general, according to the study done by Reid (2001) & Engel-Yan (2007), there are four principal strategies by which landscaping may be used, in order to reduce the amount of cooling energy required by a home:

1) The first strategy can be applied by directly shading the house with trees, shrubs or vines. The study explained that, shading the east and west sides of the house can provide the greatest cooling energy savings, since those sides face the greatest amount of summer sun. It also preferred to give the priority in shading the west over shading the east. On the other side, the study indicated that, the design should avoid planting trees on the south side of the house, as tree can block as much as 60 per cent of winter sunlight, thus making passive solar heating ineffective. This means that extended overhangs and similar devices are more appropriate for use on the south side. While, trees on the north side cannot shade the house directly, as they reduce the air and ground temperatures surrounding the house and reduce the light reflected into it.

In all cases, trees should not be planted closer than 10 or 15 feet from the home’s foundation. Because the sun’s position changes throughout the day, which directly affect the length and the orientation of the shadows it casts. This means that, the amount of shade depends on the position of the trees with respect to the sun and their proximity to the building. Actually, it is agreed that, low morning and evening sun casts shadows have length equal to 3.5 tree height, while the noon shadows have length equal to 1.7tree height. Figure (3.34) shows an example of the shadow pattern of a tree during the prime solar collection hours of 9 a.m. to 3 p.m. for a flat lot.

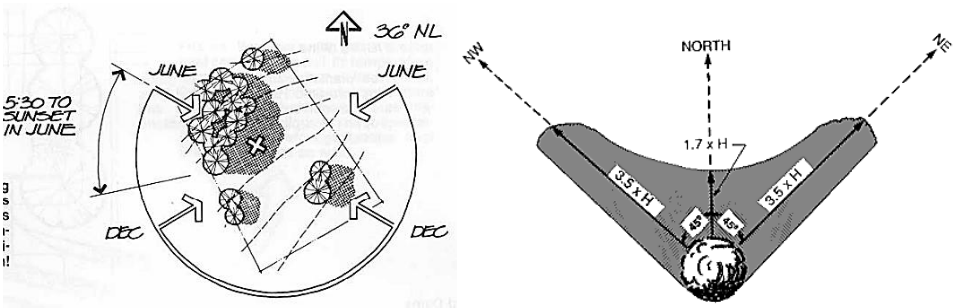


Figure (3.34): Shadows length related to tree Height.
Source: (Reid, 2001)

2) The next principle is shading the area around the house to lower the temperature of its surroundings. As it is obvious that, the shading trees can reduce summer surface temperatures and increase the pavement life of roads and parking lots. So, wherever possible, the local feasibility of planting trees and other vegetation along streets, sidewalks, large parking areas and other paved open spaces should be considered. Additionally, increasing the number of street trees by reducing standards for spacing street trees and use double rows where possible, in order to provide more shade areas and store carbon.

3) The third strategy can be applied by using ground covers to reduce sunlight reflected into the house and lower the surrounding ground temperatures.

4) The last strategy can be achieved by using evergreen trees and shrubs for windbreaks on the windward side. The windbreak needs to be at least as tall as the house and should be located at a distance of one to three times its height away from the house. Thus, the farther away it is from the house, the taller and wider it must be. The windbreak should also be dense, allowing 25 to 60 per cent of the air to flow through, rather than solid, because solid windbreaks create turbulence behind them. The density of the windbreak should be maintained from the ground up without major gaps, as shown in figure (3.35).

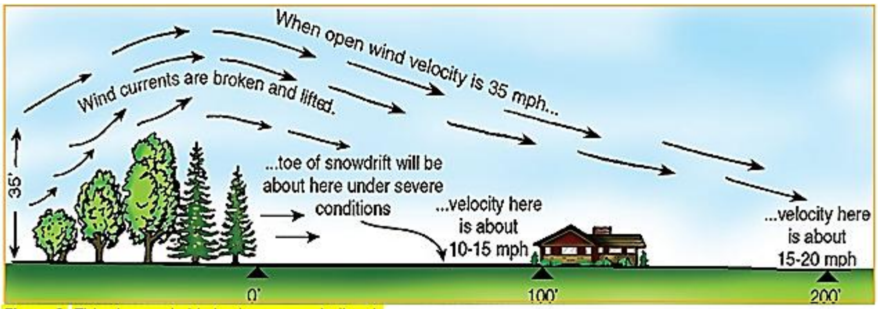


Figure (3.35): Shows wind behavior over a windbreak
Source: (Engel-Yan, 2007)

From another perspective, according to the study done by the North Carolina Solar Center at (1999), the type of trees to be planted is very important and differs according to its use. The study demonstrated that, deciduous plants such as mulberry or champa can cut off the direct sun during summer. They allow the sun to heat the buildings in winter, as these trees shed leaves in winter. Thus, the planting deciduous trees on the southern side of the building are preferred. On the other hand, evergreen trees provide shade throughout the year, while vines reduce the heat transmission through the wall or roof exposed to the sun by shading it. Consequently, the type of trees should be considered because not all trees have the same thermal and microclimatic effect. Additionally, the study also indicates that, the amount of shade depends on their shape, their height and the density of their leaves, as shown in figure (3.36- 3.37).

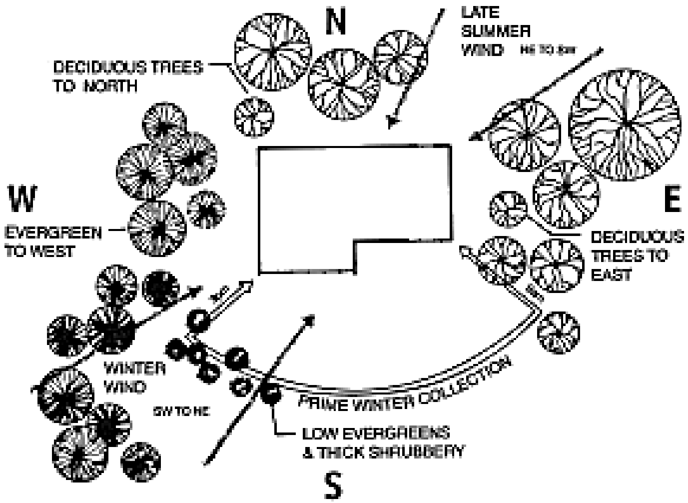


Figure (3.36): Effect of different types of trees on wind direction

Source: (Reid, 2001)

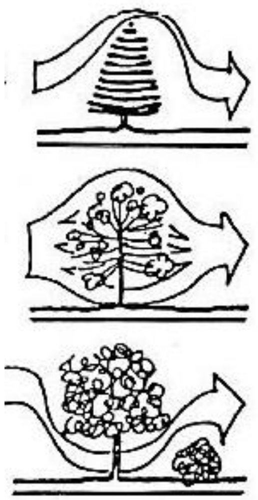


Figure (3.37): Effect of different density of trees and height on wind direction

Source: (North Carolina Solar Center, 1999)

To sum up, it can be said that, landscaping is a natural and beautiful way to keep the home cool in summer and reduce the energy bills and GHG emissions. Appropriate positioning of trees can save up to 25% of the energy which is a typical household use for energy. Many researches show that, summer daytime air temperatures can be cooler in tree-shaded neighborhoods than in treeless areas with average 3° to 6°. Additionally, the shade created by trees, grass and shrubs reduce air temperatures adjacent the building and provide evaporative cooling. Also, they show that the ambient air under a tree adjacent to the wall is about 2 °C to 2.5 °C lower than that in unshaded areas, which reduces heat gain by conduction (U.S. Department of Energy, 2009).

3.4.1.8. Exterior Block Properties:

- **Building Form / Surface-to-Volume Ratio:**

The parameter of the surface-to-volume ratio (S/V), which is determined by the building form, represents the volume of space inside a building relative to the building envelope area (Robertson, 2009). In another word, it represents the amount of exposed envelope with the surroundings, such as wind and solar incidence (Fuchs et al., 2008). This interaction between surfaces and surrounding directly affects the thermal performance of the building and the amount of heat which can be gained or lost from the space. Hence, for the ideal form, buildings are preferred to be compact with a low S/V ratio, in order to reduce heat gain and losses respectively. As, the more compacts the shape, the less wasteful it is in gaining and losing heat (Robertson, 2009). From an another perspective, this form with low S/V also represents the most energy efficient one in all climate conditions, such as the hot dry regions and as well as colder climates (Fuchs et al., 2008).

From another side, the building form can determine the airflow pattern around the building which directly affecting its ventilation. This strategy can be reduced the need for mechanical heating and cooling, as well as reduce GHG emissions that related to energy consumption. Hence, the local feasibility of using building forms that maximize energy performance should be considered, including solar energy use and minimizes unwanted solar gain. As well as building forms should minimize adverse wind effects and optimize conditions for passive ventilation and cooling. All of those factors might appear by using different solutions such as varying height, roof lines and massing, as shown in figure (3.38) (Robertson, 2009)

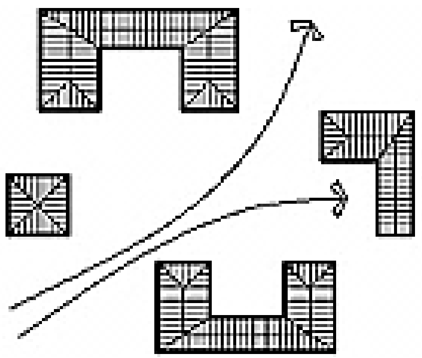


Figure (3.38): Buildings spacing which promotes the penetration of the airflow
Source: (Robertson, 2009).

- **<u>Building Shape:</u>**

As described previously that, in order to maximize the benefits of passive design, the design of the building must first and foremost minimize overall energy consumption requirements. Actually, the building's shape plays a key role in controlling energy consumption in buildings, due to its significant effect on thermal performance. In the study done by Robertson (2009) that investigated the effectiveness of building shape on reducing heating loads in the building, showed that the envelope or shell of the building is where the heat loss occurs. So, wherever possible, corners and joints must be kept to a minimum, in order to reduce the possibility of creating thermal bridges through which heat can dissipate to the outside of the building. Besides, the study also demonstrated that, the number of exterior walls should also be reduced, in order to ensure that the amount of walls exposed to the surroundings are kept to a minimum. To sum up, it can be said that the design of the building will seek to maximize the ratio of usable floor area to the outside wall area including the roof. As, the ideal design is the one which maximizes living space within a minimum envelope area, in order to minimize exterior wall surface area and associated heat gain or loss potential (Robertson, 2009).

From another perspective, the theoretical ideal shape would be a sphere, because this is a maximized volume versus a minimum envelope. The next most used shapes would be a cube, or a shape as close to a square as possible, as it is optimized to minimize corners and maximize floor area in relation to the outside wall area, as shown in figure (3.20) (Robertson, 2009).

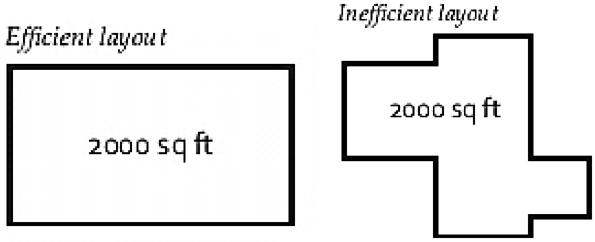


Figure (3.39): The most efficient building shape
Source: (Robertson, 2009).

- **<u>Building Size and Massing:</u>**

Successful massing should use the general shape and size of the building to minimize energy loads as much as possible and to maximize free energy from the sun and wind (Autodesk, 2011). Under hot conditions, buildings with large footprints and large amounts of floor space far from the exterior of the building will require heat removal in the interior zones all the year. The other basic planning approach is to position all spaces that can benefit from connecting to the outdoors in proximity to exterior walls. To achieve this, buildings become much narrower, with a maximum width of about 70 feet (Robertson, 2009). For example, there is a comparison carried out by Autodesk workshop in (2011) compare different mass with the same area. The result shows that, "Opt.2" has the same area as "Opt.1" but uses less than half the energy, because of better massing, as shown in figure (3.40). Thus, the main conclusion of the study is that within the same buildings' area, the linear mass offers a useful environment, in which energy loads are kept to a minimum. To sum up, it can be said that, it's important to begin considering passive design strategies in the massing stage, so that the surface areas exposed to the sun at different times of the day, building height and building width can all be optimized for passive comfort. Such an approach must be introduced very early in the design process.

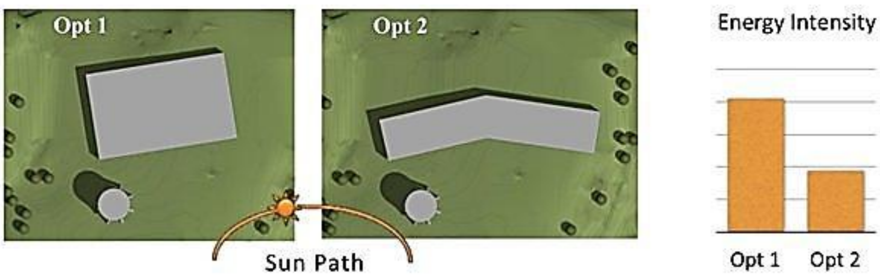


Figure (3.40): Comparison between different building mass
Source: (Autodesk, 2011)

3.4.2. <u>Architectural Scale:</u>

On the building sector, it was explained above, that the residential sector represents a large percentage of energy consumption within the built environment. It is also discussed that, a significant part of this global footprint was consumed by the buildings which the people live and work (Hoffman, 2008). This percentage according to UN-HABITAT and UNEP Report in (2009), represents almost about 40 percent of the world's energy consumption and 24% of the world's CO_2 emissions. Added to that, some researchers consider that, 55% of energy use goes for heating and cooling in the residential projects and 20% goes for the daylighting, as shown in figure (3.41) (Minnesota Department of Commerce office of energy security, 2012). Thus, if the design principles which tend to achieve thermal comfort and daylighting have been applied, almost 70% of the energy use in residential building will be reduced.

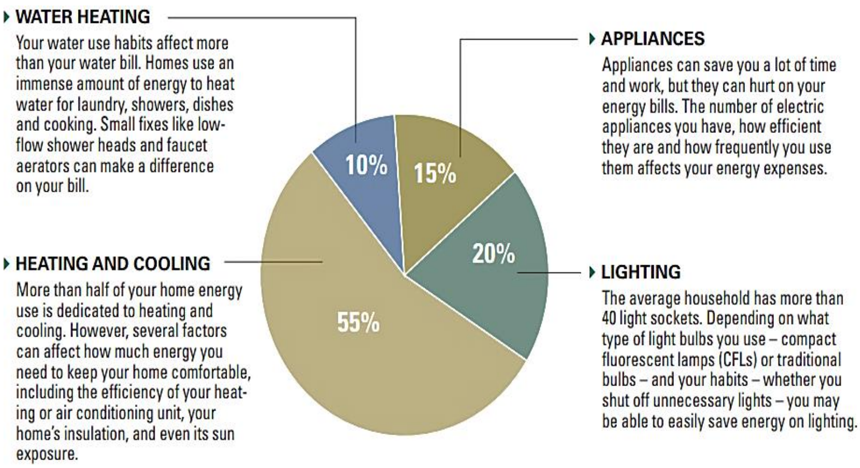


Figure (3.41): Energy consumption within residential building
Source: (Minnesota Department of Commerce office of energy security, 2012)

Hence, in this part the research tried to simplify the linkages between energy consumption and residential buildings. There are a lot of principles aimed towards energy efficiency in buildings, such as daylighting, shading, thermal mass, glass, insulation, as well as natural ventilation. In addition to other principles that focus on the efficiency of the building envelope (Hoffman, 2008). Among the various approaches and strategies to enhance energy efficiency, the designers need to recognize the large degree of interaction between all of those aspects in order to perform buildings successfully. As it is widely known that, the building's design needs to be considered as a whole system, rather than as a collection of discrete and stand-alone features (Taiao, 2008).

Consequently, this led to improve our standards and create new types of building construction that intended to reduce energy demand within buildings. Those new types vary according to the motivation and the point of view of each one, but all have the same target of decreasing energy demand (Hoyle, 2011). Among those various types, 17 different terms are identified, such as: low energy house, passive house, zero carbon house, zero energy house, energy positive house, as well as ultra-low energy house (Hoffman, 2008). Variations exist not only as regards the terms chosen, but also the energy used in the definition. Although, the minimum requirements for energy consumption has to be accomplished in the all terms (Hoyle, 2011). Those requirements include improving the thermal comfort, moisture control, noise reduction, in addition to increasing the reliability of day lighting systems, which lead to lower energy bills (Homeowner Protection Office, n.d). Thus, designers must apply holistic design principles regardless using any term from the previous terms and take advantages of the conman design principles (North Carolina Solar Center, 1999).

In general, if all of these principles are thoroughly integrated, the design will succeed to be energy efficient or can upgrade to act as a high performance building. Actually, all of these conditions can be summarized by designing an efficient building envelope. Minimizing heat transfer through the building envelope is crucial for reducing the need for space heating or cooling (Minnesota Department of Commerce office of energy security, 2012). Linguistically the word building envelope includes all the components that separate the indoors from the outdoors. The function of this envelope is to improve comfort conditions in the interior environment by protecting from heat and controlling, light, sound, ventilation and air quality (Homeowner Protection Office, n.d). In short, it can be represented by roof, walls, windows and floors of the building, a shown in figure (3.42). The efficient envelope consists mainly of components that if studied separately can significantly contribute to the total energy loss from an ordinary envelope. Among these components are advanced framing, increased insulation, windows with lower U-values and SHGC, efficient overhangs, lower absorptivity roofs, installation of Energy Star products for lighting and appliances, as well as efficient water heating equipment (Gamble & Hall, 2004).

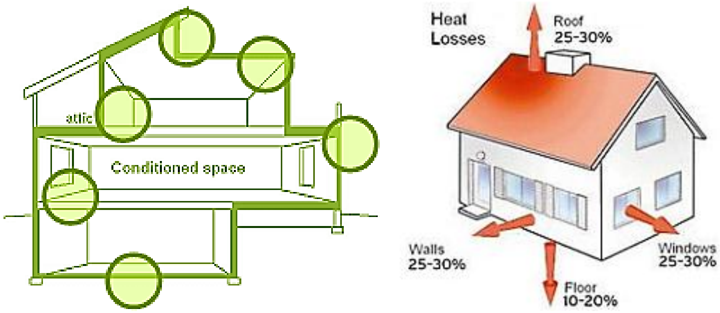


Figure (3.42): Building envelope components
Source: (Homeowner Protection Office, n.d)

To sum up, it can be said that, efficiency in energy consumption in building can be achieved through good thermal insulation, energy saving lighting, in addition to other techniques which improve the building envelope, taking into account all the environmental impacts and operating costs over the building's lifetime. Consequently, this part guides the designers to make better design decisions for long-term performance of residential buildings (Hoyle, 2011). Figure (3.43) shows an abstract diagram depicting the components of energy efficient building and its configurations.

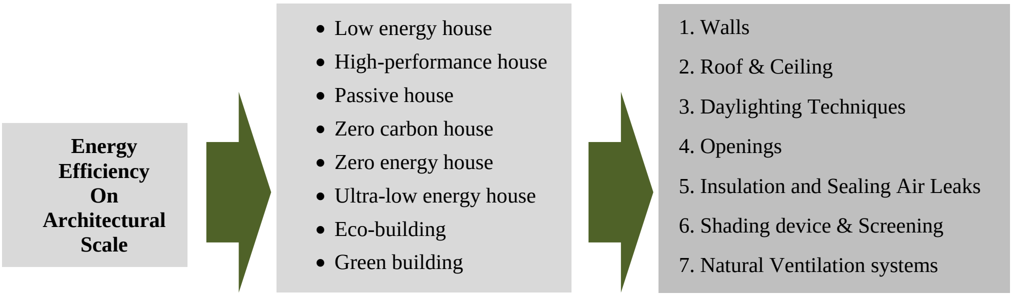


Figure (3.43): Main common principles of the architectural scale
Source: Adapted by the author

3.4.2.1. <u>Walls:</u>

In hot regions, walls' design is considered to be one of the major parts of the building envelope. This mainly returns to the reason that walls cover large areas, which leads to greater absorption of large amounts of solar radiation (Climate & Comfort, 2005). It is stated by Donnelly (2010) that, there are numerous aspects that can influence the heating and cooling loads in the building. Among those aspects are: thickness of the wall, wall colors, its material, as well as its finishes. Add to that, the study also concluded that, appropriate thermal insulation and air cavities in walls, reduce heat transmission into the building, in order to meet the desired thermal comfort conditions. In short, the walls' design strategy affects by four parameters, which mainly have an effect on building's thermal comfort conditions, those parameters are:

- **<u>Material Selection:</u>**

It is obvious that, the choice of exterior wall finishes is very important in reducing the energy contents of buildings. It is stated by Stouter (2008) that, building materials should be chosen for their initial and future performance. According to the study done by Donnelly (2010) proved that, it is worthwhile to consider the breathability in buildings, as any material being applied to the walls should be vapour-permeable. This means that, the selected material should not encourage or allow water to accumulate within the fabric of the wall.

On the other hand, the heat storage capacity and heat conduction property of the walls are keys for meeting desired thermal comfort conditions (Baker & Steemers, 2005). Actually, thermal mass can be defined according to the Autodesk workshop in (2011), as a material's resistance to change in temperature as heat is added or removed and also it is a key factor in dynamic heat transfer interactions within a building. In another study, it can be defined as the material of the building which absorbs or releases heat from or to the interior space, this material concerned is usually part of the structure or envelope (Baker & Steemers, 2005). Thus, there are three physical properties to which describes the ability of a material to store heat, which are:

- Density: It is the mass of a material per unit volume. In the Imperial system, density is given as lb/ft3; in the SI system, it is given as kg/m3. For a fixed volume of material, greater density usually permits the storage of more heat (Autodesk, 2011).
- Specific Heat: It is the measure of the amount of heat required to raise the temperature of given mass of material by 1º (Baker & Steemers, 2005). In the Imperial system, this is expressed as Btu/lb ºF; in the SI system, it is expressed as kJ/kg K. Materials with low specific heat, take less energy input to raise the temperature, while materials with high specific heat requires a lot of energy to change the temperature. For instance, one gram of water requires one calorie of heat energy to rise one degree Celsius in temperature (Autodesk, 2011). The following table (3.3) shows the specific heat required for different materials.

Material Heat capacity	**J/(g•K)**
Brick	0.84
Concrete	0.88
Granite	0.79
Gypsum	1.09
Soil	0.80
Wood	1.2 - 2.3
Water	4.2

Table (3.3): Specific heat capacity of building materials
Source: (Autodesk, 2011)

- Thermal capacity: This term is an indicator of the ability of a material to store heat per unit volume. The greater the thermal capacity of a material, the more heat it can store in a given volume per degree of temperature increase (Baker & Steemers, 2005). It was obvious that, the thermal capacity of a material is obtained by taking the product of density and specific heat. Higher thermal capacity can reduce heat flow from the outside to the inside environment by storing the heat within the material. It is stated in the Autodesk workshop that, the thermal capacity of any material can be calculated according to the following equation:

Thermal Capacity (Thermal Mass): Density x Specific Heat = How much heat can be stored per unit volume

To sum up, it can be said that reducing the strain on conventional energy can be achieved by low energy buildings with low energy materials (Stouter, 2008). Actually, materials are comfortable in hot weather if they do not hold much heat. Thus, the preferred materials to be used is typically the one which can be produced with lesser energy, it can be summarized in dense material such as concrete, brick or stone (Baker & Steemers, 2005). On the other hand, material with low embodied energy, as locally available materials should be used over materials that need to be brought in from distant places (Stouter, 2008).

- **Wall Orientation:**

As it is widely known that, the walls provide protection from climatic elements such as heat, rain, wind and dust. The study of Climate and Comfort (2005) obvious that, by depending on the orientation of the walls, the exposure to solar radiation varies considerably. As described previously that, walls facing the north do not receive direct solar radiation, while south facing walls receive a high intensity of solar radiation (Robertson, 2009). On the other hand, east and west-facing walls receive direct solar radiation only for part of the day (Robertson, 2009). To sum up, it can be said that the design of the building's form can reduce or increase the surfaces of walls, which are subject to incidence of solar radiation (Climate and Comfort, 2005).

- **Wall Insulation Strategy:**

It is acknowledged that, wall insulation is a very important factor to reduce the heating and cooling loads in a building. This may be extended to its importance in moderating the internal temperatures by averaging day/night, increasing comfort and reducing energy costs. The study done by Stouter (2008) showed that, it is preferred to use externally insulated, dense materials like concrete, bricks and other masonry. As it is agreed that, those materials are the most common materials used in passive design, as they absorb, store and re-release thermal energy. Figure (3.20) shows the relation between material thickness and how much of the heat it holds in different types of materials.

Material- thickness	How much heat it holds (btu/in/8F)	Insulation (R value)
Solid concrete- 15cm	2.2 times better (15)	Insulates the worst (0.5)
Fired bricks- solid 10 cm	4.1 times better (8)	1.6 times better (0.8)
Fired bricks- rat trap 20 cm	3.3 times better (10)	2.8 times better (1.4)
Hollow conc. block- 20cm	4.1 times better (8)	2.2 times better (1.1)
CEB- 20cm	1.9 times better (17)	4.4 times better (2.2)
Mud block or cob- 40cm	Holds the most heat- (33)	8.8 times better (4.4)
Light earth – 48cm	1.7 or more times better (19)	11 + times better (5.3)

Table (3.4): Illustrate the relation between material thickness and how much of heat it holds
Source: (Stouter, 2008)

On the other hand, it is also preferred to use two-layer insulation approaches to reduce thermal bridging. The study of Climate and Comfort (2005) explained that, it is mainly depends on installing energy efficient cladding systems in the building. This system has a higher thermal resistance and fewer thermal breaks than typical cladding systems, consequently less energy is required to heat and cool the building. The result of the study showed that, there are two of the most common energy efficient cladding systems in the market today, which are exterior insulation and finish systems (EIFS) and insulated metal wall panels. The term EIFS can also be defined as a lightweight cladding that can imitate the appearance of numerous building materials, including brick, stone, metal panels, siding and stucco, as shown in figure (3.44) (EIFS Industry Members Association, 2014).

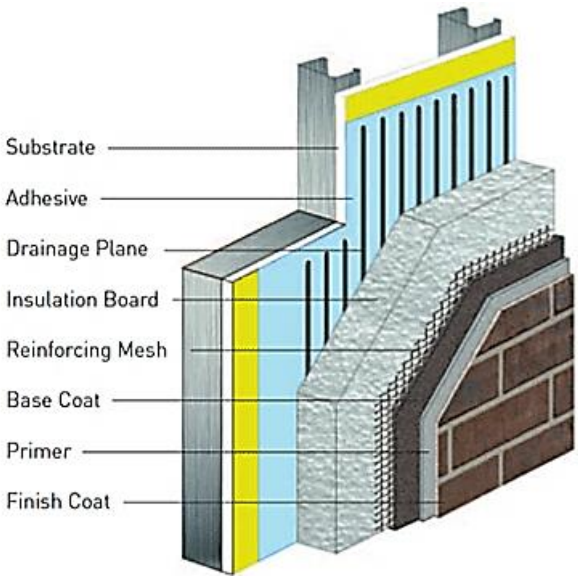


Figure (3.44) EIFS insulation layer which can be used
Source: (EIFS Industry Members Association, 2014)

- **Paint color:**

As described previously that, exterior surface colors for the building's walls influence directly the heating and the cooling load of the building. Thus, the color of the material should be considered in order to reduce the absorption of sun's heat which consequently reduces the energy demand. To sum up, it can be said that in warmer climates, lighter colored materials are the preferable to be used. As, it was obvious in the study done by Allen & McKeever (1996) that, the dark colors (low-albedo) on walls absorb heat into the building itself, which then requires an additional amount of energy needed to cool the building. While, the light color on walls decrease absorption of the sun's heat and helps maintain cooler temperatures within the building.

3.4.2.2. Roof & Ceiling:

The roof is another component which is highly exposed to solar radiation and it is difficult to be protected. So, the proper treatment of the roof is very essential, as it plays an important role in daylighting, ventilation and gaining or losing heat (Hoyle, 2011). According to the study of Climate and Comfort (2005), there are two issues should be addressed during successive design stages: the first is its protection from sun rays during summer to minimize heat gain and the second is its exposure to the sun rays in winter to maximize heat gain. The main parameters that affect the heat flow through the roof are:

- **Roof Form:**

It is critical to consider the form of the roof, in order to maximize energy efficiency within the building. There are numerous forms in which the roof can be designed, among those aspects are: flat, arched, domed as well as pitched roof (Hoyle, 2011). According to the study of Climate and Comfort (2005), the flat roofs absorb heat throughout the day, this is consequently meant that heat gains from a flat roof can be excessive unless a cavity ceiling can be made below the roof. Moreover, it is obvious that the domed, arched and pitched roofs offer an advantage over the flat roof. This may be extended to reason that, these roof forms have a part of the roof directly under the sun and part of it in the shade. The exposed part builds up heat, then transfers this heat to the shaded cooler part, this heat exchange process is effective in reducing heat build-up. Thus, to sum up, it can be said that the design of the roof affects directly the heating load inside the building.

- **Roof Insulation;**

In a hot region, the roof should have enough insulating properties to minimize heat gains. The most common types of flat roofs, listed in order of increasing insulation are: roll asphalt, single-ply membrane, multiple-ply or built up, flat seamed metal and green roofs (Climate and Comfort, 2005).

I. Asphalt Roll Roofing: Consists of one layer of asphalt-saturated organic or fiberglass base felts.
II. The most common materials in single-ply roofs are thermoset, thermoplastic and modified bitumen.
III. Green roofs: A green roof typically can be considered as a good type of an excellent insulation system (Liu, 2002). There are two types of green roofs: intensive roofs, which are thicker and can support a wider variety of plants but are heavier and require more maintenance. While extensive roofs, which are covered in a light layer of vegetation and are lighter than an intensive green roof (Sustainable Building Methods, 2009). In short, intensive green roofs are more common with large businesses or government buildings rather than freestanding homes, as they add considerable load to a structure of the building.

In general, the both types of the green roof can effect directly in reduced heating and cooling loads on a building by fifty to ninety percent (Sustainable Building Methods, 2009). According to the study by Liu (2002) showed that, green roofs can help in the extension of the life of the roof membrane because of protection from intense ultraviolet radiation. The study also argued that, it can be used as noise insulation, as the soil helps to block lower frequencies and the plants block higher frequencies. On the other hand, the green roofs have an indirect effect on the outdoor environment, as they help in improving air quality as the plants absorbs and converts carbon dioxide to oxygen (Sustainable Building Methods, 2009). It is also agreed that, they help in cooling the surrounding environment and can even reduce the city's average temperatures during the summer. Besides, they can potentially increase the area of habitat for wildlife such as birds and insects (Liu, 2002). On the other side, the main disadvantage of green roofs is the high initial cost as well as the maintenance costs. Some kinds of green roofs also place higher demands on the waterproofing system of the structure because water is retained on the roof and also due to the possibility of roots penetrating the waterproof membrane (Sustainable Building Methods, 2009). Figure (3.45) shows a comparison between the rooftop garden and the ordinary roof (Liu, 2002).

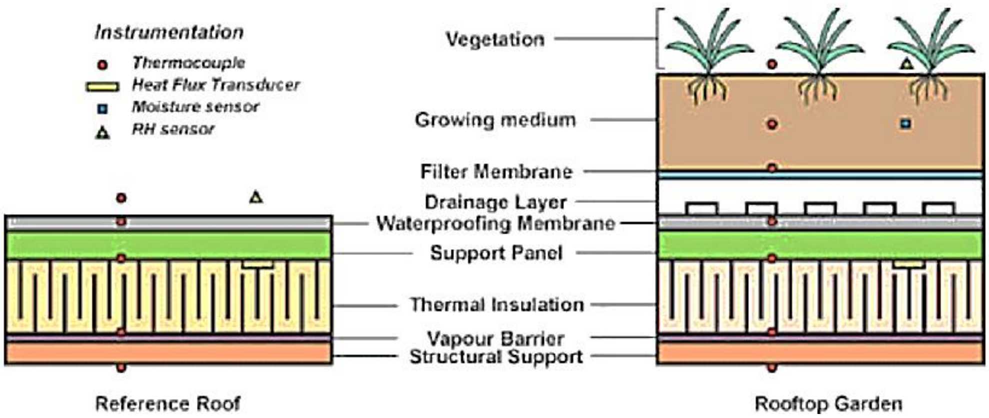


Figure (3.45): The comparison between the rooftop garden and the ordinary roof
Source: (Liu, 2002)

- **<u>Roof Color & Reflectivity:</u>**

Covering membranes with materials that reflect ultraviolet and infrared radiation will reduce damage caused by u/v and heat degradation. It is also worth mentioning that, it is preferred to use a roof system that can deliver high solar reflectance, as it has the ability to reflect the visible, infrared and ultraviolet wavelengths of the sun and reducing heat transfer to the building. On the other side, it has a high thermal emittance, which is the ability to radiate absorbed, or non-reflected solar energy. In general, this system can be represented by using cool roof system. It is stated by Hoyle (2011) that, cool roofs are inherently reflective and can achieve some of the highest reflectance and emittance measurements of which roofing materials are capable. For example, a roof made of thermoplastic white vinyl, can reflect 80 percent or more of the sun's rays and emit at least 70% of the solar radiation that the building absorbs. While an asphalt roof only reflects between 6 and 26% of solar radiation, resulting in greater heat transfer to the building interior and greater demand for air conditioning (Hoyle, 2011).

The study by Hoyle (2011) also agreed that, most cool roofs are white or other light colors. Furthermore, it is preferable to use light colored materials and avoid dark paints for roofs. As described previously, in the study done by Allen & McKeever (1996) that, dark colors (low-albedo) on roofs absorb heat into the building, which then requires additional energy to cool the interior of the building and this directly raises the cooling demand of the building during the summer time. While, the light color (high-albedo) reflect sunlight and helps maintain cooler temperatures within the building and this consequently cut the amount of energy demand. On the other side, the way to make an existing or new roof reflective is by applying a solar reflective coating on its surface. These coatings are specially engineered to reflect heat, as regular white paint is not enough. It is worthwhile to consider that, ceramic coatings are the most well-known in this domain, they provide an average reflectance of 75% to 85% (Hoyle, 2011). Figure (3.46) illustrates a comparison between the performance of a cool roof and uncoated roof.

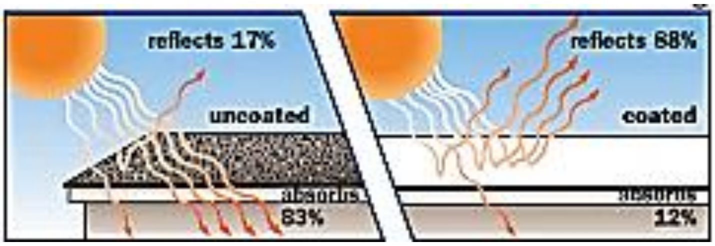


Figure (3.46): Illustrates a comparison between the performance of a cool roof and uncoated roof
Source: (Hoyle, 2011)

To sum up, it can be said that the cool roofs with high reflective material is the preferred type to use on the roof surface. As, cool roofs offer both immediate and long-term savings in building energy costs. In addition to that, they reduce building heat gain, as they create 15–30% savings on summertime air conditioning expenditures. As well as, they enhance the life expectancy of both the roof membranes. Consequently, they reduce the resulting air pollution and greenhouse gas emissions (Hoyle, 2011). Table (3.5) represents a list of light colored and reflective materials.

ROOF MATERIALS	SOLAR REFLECTANCE (ALBEDO)	INFRARED EMITTANCE	TEMPERATURE RISE
Gray EPDM	0.23	0.87	68°F
Gray asphalt shingle	0.22	0.91	67°F
Unpainted cement tile	0.25	0.9	65°F
White granular surface bitumen	0.26	0.92	63°F
Red clay tile	0.33	0.9	58°F
Light gravel on built-up roof	0.34	0.9	57°F
Aluminum coating	0.61	0.25	48°F
White-coated gravel on built-up roof	0.65	0.9	28°F
White coating on metal roof	0.67	0.85	28°F
White EPDM	0.69	0.87	25°F
White cement tile	0.73	0.9	21°F
White coating, 1 coat, 8 mils	0.8	0.91	14°F
PVC white	0.83	0.92	11°F
White coating, 2 coats, 20 mils	0.85	0.91	9°F

Table (3.5): list of light colored and reflective materials
Source: (Green Building Platinum series, 2010)

3.4.2.3. Daylighting Techniques:

Daylighting and access to natural sunlight are essential for living spaces, as this quality of light promotes occupant comfort. From the other side, daylighting access replaces artificial lighting, as it helps in reducing energy demand and maximizes energy efficiency within the building. Thus, it is extremely important to consider daylighting strategies from an overall perspective. There are some building codes use daylight factors as the design criteria instead of illuminance on the working plane (Taiao, 2008, Hoyle, 2011). Briefly, daylight factor can be expressed according to Autodesk workshop, as the percentage of natural light falling on a work surface compared to that which would have fallen on a completely unobstructed horizontal surface under same sky conditions. The study agreed that, daylight factor of 5% on an internal surface means that it received 1/20th of the maximum available natural light. Also proved that, it is preferred to design rooms with daylight factor between 2% and 5%, as it is considered the ideal percentage for activities that commonly occur indoors. In short, to consider the preferred daylight factor within any building, there are common designs strategies from an overall perspective must first be applied, among these strategies are:

- **Site Conditions:**

The previous studies and the researchers showed that, it is quietly important to use information from the site investigation to choose suitable building orientation, form type, orientation and internal layout. For example Taiao (2008) recommended that, building layout should be responding to the path of the sun, providing a sufficient supply of natural daylight through windows. As, it is widely known that, the actual illuminance levels in the space from daylighting can vary greatly due to the cloud cover and the position of the sun (Autodesk, 2011). Thus, it is important to consider the appropriate site conditions while making decisions about lighting, in order to reduce the need for artificial lighting and thus improve occupant comfort.

- **Buildings' Mass:**

There are some general strategies for using massing to maximize daylighting energy and comfort. The study by Taiao (2008) concluded that, selecting an appropriate building footprint can allow the building to maximize the use of the daylight available. It was proved by the study that; the daylighting strategy will only be effective up to a maximum distance of around 15 meters over an open plan layout. Generally for good daylighting, buildings that are longer on their east-west axis are better for daylighting and visual comfort , as shown in figure (3.47) (Autodesk, 2011). Consequently, long narrow sections buildings are preferable than square ones, in order to maximize daylighting potential from side windows (Taiao, 2008). On the other hand, large buildings can get daylight into more spaces by having central courtyards or atria, or having other cutouts in the building form (Autodesk, 2011). Figure (3.48) shows some examples of layouts that distribute and use daylight effectively.

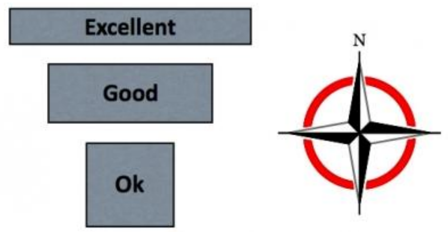


Figure (3.47): Better and worse massing for daylighting
Source :(Autodesk, 2011)

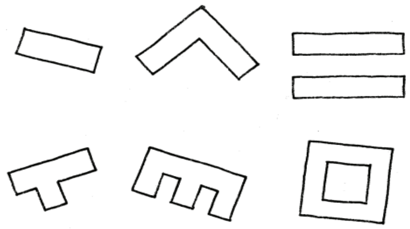


Figure (3.48): Building footprints for best daylight access
Source: (Taiao, 2008)

- **<u>Window Position</u>:**

Windows on every orientation can provide useful daylight, but each orientation needs to be treated differently. Good passive design should situate windows in multiple directions in order to balance interior lighting requirements (Robertson, 2009). According to the Autodesk workshop in (2011), it is very difficult to get consistent daylight and control glare from east and west windows. While, north facades provide good access to strong illumination, but vary throughout the day and require shading. On the other hand, the study by Taiao (2008) also demonstrated that, south facades provide high-quality, consistent daylight with minimal heat gains, but thermal loss occurs on cooler days. Thus, it can be said according to the study by Robertson (2009) that, the north/south exposures are generally preferable to east/west preferably within 30 degrees of the north/south axis, as shown in figure (3.22).

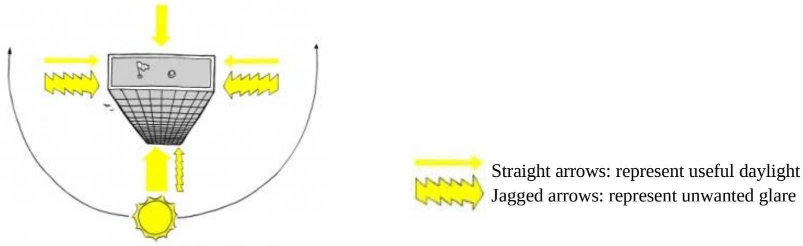


Figure (3.49): Useful daylight and unwanted glare on different faces of a building.
Source: (Autodesk, 2011)

On the other side, increasing the height of each storey to allow higher windows, also helps in pulling daylight further into the building (Green Building Platinum series, 2010). According to the study done by Taiao (2008), the practical depth of a daylight zone coming from normal side windows can typically limited to 1.50 times the window head height. It is agreed that the higher the window, the deeper the daylight reaches into the room. Thus, it is preferred to consider slightly larger floor-to-floor heights and providing glazing above 2,100 mm. This consequently enables natural light to penetrate deeper into the spaces (Green Building Platinum series, 2010). It is also agreed that, daylight glazing is most effective above 2,100 mm, as shown in figure (3.50). On the other hand, it is noted that, for two-sided daylighting the room width can be between 3 to 4 times the window head height. While, in the case of one sided daylight, room depths should be within 1.5 to 2 times window head height for adequate light levels and balanced distribution (Taiao, 2008).

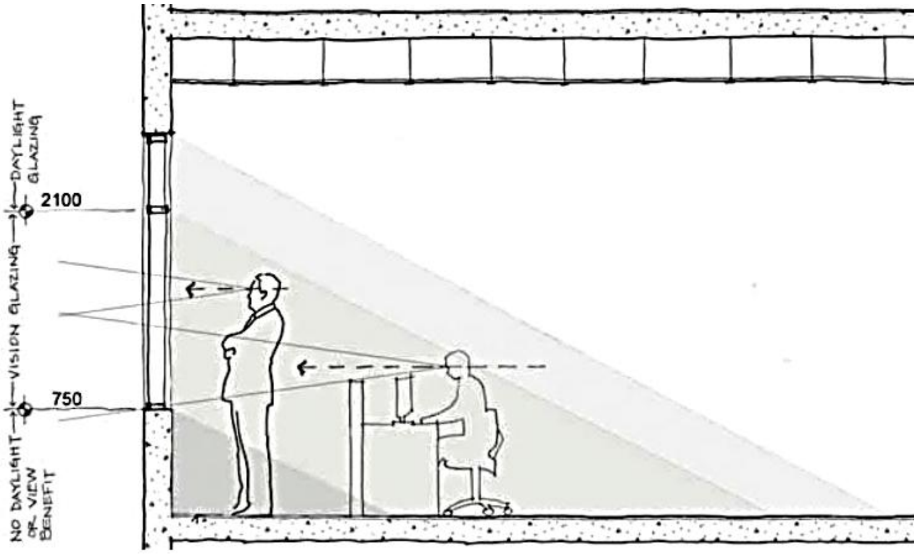


Figure (3.50): Effective height of daylight glazing
Source: (Green Building Platinum series, 2010)

- **<u>Using Skylights:</u>**

By using skylights, buildings can easily achieve good daylighting throughout, no matter how wide they are. Although skylights can bring in lots of natural daylight, they are a source of heat loss in the winter and heat gain in the summer. So, the good design should take in consideration the good type of skylight, to prevent heat loss (Taiao, 2008). According to the study by Autodesk (2011) which concluded that, top lighting apertures are much brighter than side lighting apertures, this means that less area is required. In order to calculate this area, it is preferred first to identify the Skylight-to-Roof ratio. This ratio can be defined as the net glazing area divided by the gross roof area, this SRR ratio should be between 3% and 6%. For example, to size a rectangular skylight, this simple formula can be used:

Area of one skylight = (Floor to Ceiling Height x 1.5)^2 • target SRR

Besides choosing the right size, it is quietly important to select the type of the skylight. There are numerous types that can be used to bring lots of natural daylight inside the building, as shown in figure (3.51). Among those aspects are: solar tubes, clerestory windows, light duct, roof monitors, atriums, as well as clerestory. All of them are simpler to install and provide daylight into the house without the associated heat gain (Robertson, 2009).

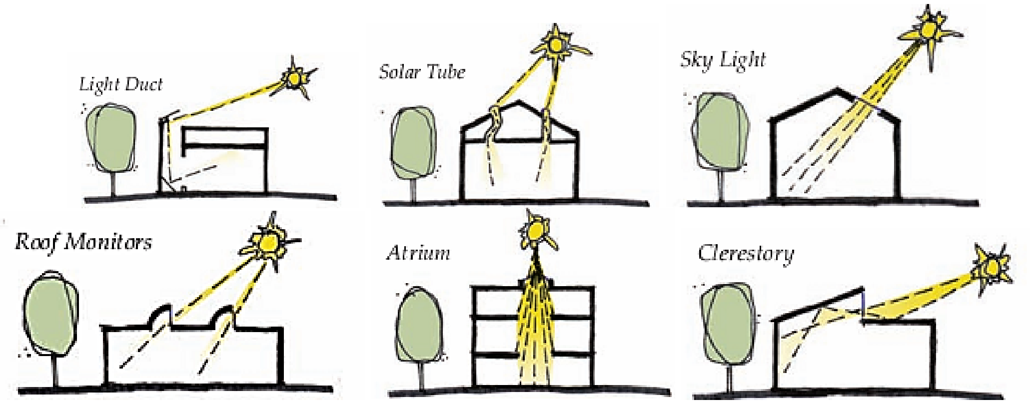


Figure (3.51): Different types of skylight windows
Source: (Robertson, 2009)

3.4.2.4. <u>Openings (Windows):</u>

Windows are typically the weakest link in the building's thermal barrier, as they are parts that caused easily energy loss, as shown in figure (3.52) (Miglas, 2013). It was stated by that, windows can negatively impact a home's energy efficiency, comfort, as well as the indoor air quality if they not properly selected and installed (ASHRAE, 2001). From another perspective, the energy efficient windows cost more than standard models, although they can cut energy bills significantly and reduce heating and cooling loads needs in the house (Technology Fact Sheet, 2000). Therefore, considering energy efficient options for the fenestration system is an important energy savings strategy.

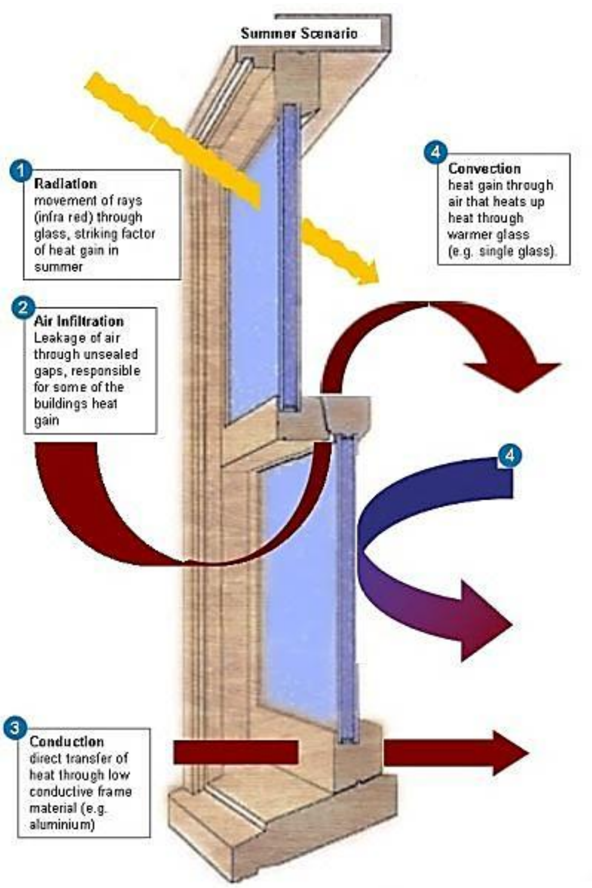


Figure (3.52): Illustrates heat losses through the opening
Source: (Miglas, 2013)

The energy efficient options for the fenestration system are mainly depending on the proper selection of windows, in order to minimize a home's heating, cooling and lighting costs. Achieving the effective window selection in a house depends mainly on three step process: (Technology Fact Sheet, 2000):

- **<u>Design Step:</u>**

Passive solar features and their impacts on the windows should be considered during the design stage. For a naturally ventilated building, size, types, properties and placement of windows relative to wind movements should also be determined as an integral part of the whole house design (ASHRAE, 2001). It is stated by Hoyle (2011) that, passive solar design strategies vary by building location and regional climate, but the basic techniques involving windows remain the same in order to maximize solar heat gain in winter and minimize it in summer.

The first step in the design stage is how to determine the effective window to wall ratio (WWR). It is quite important to define it according to the study by the Autodesk workshop in (2011) as it is the ratio between the net glazing areas in relation to the gross wall area, as shown in figure (3.53). As it is widely known that, the net glazing area refers to only the transparent part of the window and it does not refer to mullions or framing. This area is usually around 80% of the gross window area. On the other hand, the gross wall area mainly represents the full floor to floor exterior height of the wall. The study also concluded that, the window to wall ratio should be 40% or lower for adequate insulation in cold climates, while in warm climates, higher ratios can be acceptable, as long as the windows are well shaded from the sun's heat.

Figure (3.53): Illustrates the window to wall ratios
Source :(Autodesk, 2011)

On the other side, it is quietly important to remember that, windows are the source for thermal bridges. Therefore, the appropriate number of windows will mitigate unnecessary heat loss or gain. The study by Robertson (2009) concluded that, windows ratio should not exceed 2/3 of the envelope. Moreover, it is preferred to not over glaze and minimize the number of windows, as they can cause too much heat loss or heat gain, or too much brightness and glare, as shown in figure (3.54) (Autodesk, 2011). To sum up it can be said that, the number of individual windows should be kept to a minimum, as it is only preferred to choose the right sizes for windows. Added to that, it's worthwhile to mention that one slightly larger window is more efficient than two windows, even if they are equal in the area (Robertson, 2009).

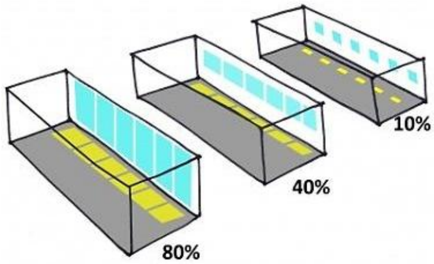


Figure (3.54): Different window to wall ratios and the resulting illumination
Source: (Autodesk, 2011)

Another metric to pay attention for proper glazing for side windows is the window-to-floor Ratio (WFR) (Autodesk, 2011). According to the study by Robertson (2009) which concluded that, the total window area should not exceed 8 to 9 per cent of the floor area. While the study by Autodesk (2011) put a rule for side lighting thresholds which are the Window-to-Floor ratio, multiplied by the visible light transmittance (VLT) of the windows, should be between the following two values:

$$0.15 < VLT \bullet WFR < 0.18$$

The second step in the design stage is the selection of the type of windows, as the style of the window will also have an effect on its performance. There are numerous types of windows, among those types are: slider window, fixed window as well as hinged one, see figure (3.55) (Technology Fact Sheet, 2000). It was obvious in the study by Robertson (2009) that, slider windows may be poorer air barriers as the sealing system is harder to design, while fixed windows are permanently sealed but do not offer the benefits of ventilation. On the other side, hinged windows can be used, in which compression seals that are sturdier than slider windows, but may still wear out and issues arise when worn out seals are not replaced.

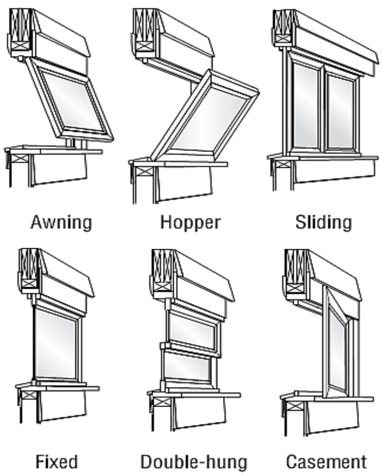


Figure (3.55): The different style of windows
Source: (Technology Fact Sheet, 2000)

The third step is the effective place of windows, as described previously that in hot climates north-south facing windows are the most preferred, as they are used just to provide useful lighting. While the east- and west-facing windows should be limited because it is difficult to effectively control the heat and penetrating rays of the sun when it is low in the sky.

- **<u>Selection Step:</u>**

Window properties that meet the design goals should be specified using applicable guidelines (Robertson, 2009). Windows should be selected in order to meet the specified design properties after considering the window technologies that improve performance. It is worth mentioning that, heat is lost and gained through windows by direct conduction through the glass, frame and the air leakage around the window. This approach is mostly discussed in Technology Fact Sheet (2000) which approved that, the window selection is based on four measured criteria corresponding to heat loss and gain methods, among those criteria are:

• U-factor: This factor is a measure of the rate at which a window conducts non-solar heat flow, usually expressed in units of Btu/hr-ft2-°F. The U-factor may not refer to the glass alone, but it also represents the performance of the entire windows, including the frame and spacer materials (Hoyle, 2011). A window with a lower U-factor is more energy efficient than one with a higher U-factor. In general, window U-factors ranges from 0.2 to 1.2 (Technology Fact Sheet, 2000).

• Solar heat gain coefficient (SHGC): The SHGC is the fraction of solar radiation admitted through a window, which transmitted directly and absorbed by the window and subsequently released as heat inside the home. The lower the window's SHGC, the less solar heat it transmits and the greater it's shading ability (Hoyle, 2011). As it is widely known that, the window with a high SHGC is more effective at collecting solar heat gain during the winter, while the window with a low SHGC is more effective at reducing cooling loads during the summer by blocking heat gained from the sun. In general, SHGCs ranges between 0 and 1(Technology Fact Sheet, 2000).

• Air Leakage: Air leakage is a measure of the rate of air infiltration around a window in the presence of a specific pressure difference across the window (Hoyle, 2011). It is quite important to express it in units of cubic feet per minute per square foot of frame area (cfm/ft ^{2}). A window with a low air leakage rating is tighter than a window with a high air leakage rating. In general, air leakages are usually less than 1(Technology Fact Sheet, 2000).

• The visible transmittance of the window (VT): VT is the fraction of the visible spectrum of sunlight weighted by the sensitivity of the human eye, which is transmitted through the window's glazing (Hoyle, 2011). Actually, it is widely known that, the window with a higher VT transmits more visible light. In general, VT is expressed as a number between 0 and 1(Technology Fact Sheet, 2000).

So, to meet the requirements of the passive house standard, windows are manufactured with exceptionally high low U-values, typically 0.85 to 0.70 W/ (m².K) for the entire window including the frame (Hoyle, 2011). On the other side, south facing windows usually must have a SHGC of greater than 0.6 to maximize solar heat gain during the winter, a U-factor of 0.35 or less to reduce conductive heat transfer and a high visible light transfer. While, east-west-facing windows should have low SHGC in addition to that, they should be limited in size (Technology Fact Sheet, 2000). On the other side, the energy impacts of fenestration can be optimized by using different type of glazing with special transmission properties (Eley, 1991). As it is widely known that, the heat flow through fenestration can be controlled by various kinds of glazing, as the overall quality of a window can be determined by the thermal quality of the glass and the frame (ASHRAE, 2001). There are numerous types that the selection of the window glaze depends on. Among those types are:

• <u>Insulated glazing:</u> Insulated glazing actually has another name, which called double glazing or triple glazing (Eley, 1991). This type refers to windows with two or more panes of glass, these panes are spaced apart and hermetically sealed to form a single glazed unit with an air space between each pane of glass. The main impact of this type of glass is to resist heat flow, in addition to lowering the U-factor and SHGC (Robertson, 2009). Figure (3.2) shows the relation of different number of layers with the amount of heat they resist.

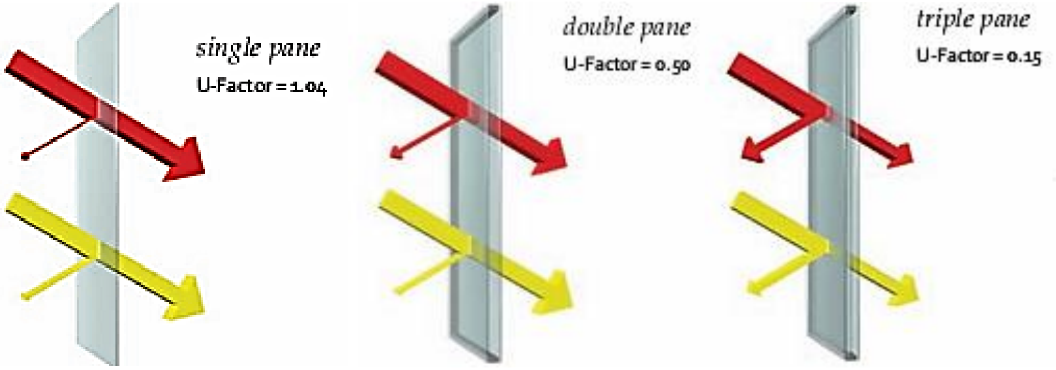


Figure (3.56): The glass layers and the air spaces resist heat flow
Source: (Ele, 1991)

• <u>Reflective glass:</u> Reflective glass is coated to reflect radiation striking the surface of the glass. This reflective coating usually consists of thin metallic layers and comes in various metallic colors like silver, gold and bronze (Eley, 1991). It is widely known that, the reflective glass reduces the passage of solar radiation through the window, generally blocking more visible light than heat (Robertson, 2009). It reduces SHGC and greatly reduces VT and glare. Reflective glass is most useful in hot climates in which solar control is critical (Eley, 1991).

• <u>Heat-absorbing or tinted glass:</u> Heat-absorbing glass contains special tints that change the color of the glass. Actually, this type of glass absorbs a large fraction of the incoming solar radiation, which reduces SHGC, VT and glare (Eley, 1991). Grey and bronze tints reduce the penetration of both visible light and heat into buildings in equal amounts and are the most common colors used. While, the blue and green tinted windows offer greater penetration of visible light and heat (Robertson, 2009). Heat-absorbing glass reflects only a small percentage of light and therefore does not have the mirror like appearance of reflective glass (Eley, 1991).

• <u>Low- emittance coating glass:</u> Coating a glass surface with a low-emissivity (low-e) metallic oxide material significantly reduces the amount of heat transfer. The improvement in insulating value due to this coating is roughly equivalent to adding another layer of glasses to the multi-pane glass unit (Eley, 1991). For example, two panes of glass coated with low-e will have about the same insulating value as three clear panes, as shown in figure (3.57). Add to that, if argon gas added between these two panes, the system will be nearly as effective as four layers of clear glass (Robertson, 2009). This coating is optically designed to reflect particular wavelengths and be transparent to others. Such a coating is commonly used to reflect the infrared portion of the solar spectrum and creating the window with a low U-factor and low SHGC, but with a high VT (Technology Fact Sheet, 2000).

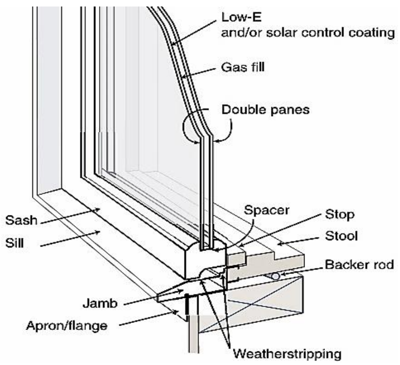


Figure (3.57): Low- emittance coating glass filled with argon gas
Source: (Technology Fact Sheet, 2000)

- **<u>Installation Step:</u>**

The last process to achieve the energy efficient window system is the installation. Even the most energy efficient window must be properly installed to ensure that its energy performance is achieved and the window does not contribute to building moisture problems (Technology Fact Sheet, 2000). Window installation varies depending on the type of house construction, exterior cladding and the type of weather resistive barrier being installed. On the other hand, the window opening must be flashed and integrated into the home's weather resistive barrier, so that any potential water leaks do not cause damage. Moreover, windows must also be properly air-sealed during installation to perform correctly. To air seal the window, caulk the backsides of the window mounting flanges to the weather resistive barrier during installation (Eley, 1991). From inside the house, it is better to seal the gap between the window frame and the rough opening using backer rod and caulk or non-expanding latex-based spray foams that will not pinch jambs or void window warranties (Technology Fact Sheet, 2000). Metal window frames should have a thermal break insulating plastic strip placed between the inside and outside of the frame to reduce heat flow and the window U-factor, as shown in figure (3.58) (Eley, 1991).

Figure (3.58): Thermally-broken window frame
Source :(Autodesk, 2011)

Finally, there are sources of guidance to help in the specification of windows, they actually determined the minimum requirement of windows design (Technology Fact Sheet, 2000). Among those sources are:

• <u>2000 International Energy Conservation Code:</u> Windows should be selected in accordance according to the 2000 International Energy Conservation Code. This code shows that, the U-factor required for a specific climate may be dependent on the window's area which installed or the efficiency of other elements of the house depending on the compliance approach chosen. The air leakage rating must be less than 0.3 and the SHGC must be less than 0.4 if the heating degree days are less than 3,500 (Technology Fact Sheet, 2000).

• ENERGYSTAR®: Energy Star is a federal initiative that helps consumers to identify energy efficient products, including windows and skylights. Windows carrying the Energy Star label use less energy than standard products for three major climate regions across the country (Technology Fact Sheet, 2000). All Energy Star windows must carry the NFRC certification label (Autodesk, 2011). Figure (3.59) shows an example of the Energy Star window qualification guidelines by climate group.

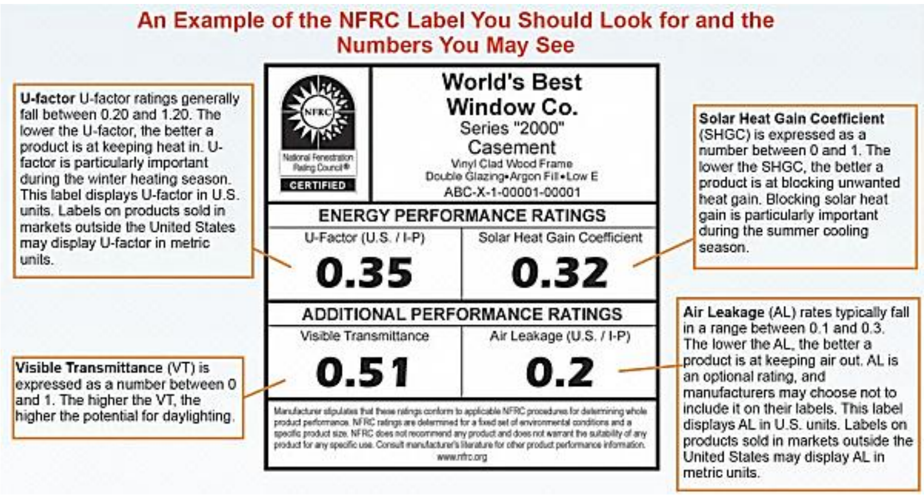


Figure (3.59): Certifying window thermal performance
Source :(Autodesk, 2011)

To sum up, it can be said that, the careful choice of windows and proper tightly sealed installation contributes to a better building envelope and can lead to significant energy savings. When compared to older, single-pane windows, installation of new tightly sealed, single-pane windows provide significant cost savings, but the use of double-pane, low-e windows can increase annual savings by a factor of four. Also, it is preferred to install ENERGY STAR windows instead of the regular windows. So, wherever possible, multiple pane, low-e and gas-filled window configurations, or super windows that combine all the above advanced features are recommended in cold climates. While, in hot climates less expensive glazing with low-e coatings, gas fills and shading are the most cost effective energy saving options. Besides glazing characteristics, insulated frames and spacers, good edge seals and airtight construction are equally important for energy efficiency.

3.4.2.5. Insulation:

Checking your home's insulation is one of the fastest and most cost effective ways to reduce the most critical determinant of energy waste and interior thermal comfort (Taiao, 2008). A good insulating system should be carefully considered to achieve the best result, this system includes a combination of products and construction techniques that protect the home from outside temperatures, also against air leaks as well as control moisture (U.S. Department of Energy, 2009). It was stated by Taiao (2008) that, thermal insulation slows the transfer of heat through walls, floors and ceilings, both inwards and outwards, as shown in figure (3.60). These results in reducing energy costs, also helps in maintaining a uniform temperature by retaining heat during the winter months, as well as keep the building cool during the summer months.

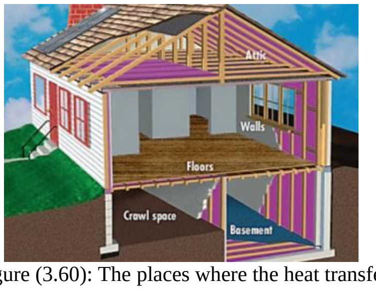


Figure (3.60): The places where the heat transfer
Source: (U.S. Department of Energy, 2009)

Thus, it is worth mentioning that, proper insulation and sealing air leaks in buildings are important factors in achieving thermal comfort for occupants, as well as they help to reduce the energy demands of heating and cooling systems, as shown in figure (3.61, 3.62). It is stated in the study done by Taiao (2008) that, the proper design strategies for insulation are rated by R-value, which measures resistance to heat flow. This study argued that the higher the R-value, the better the walls and roofs will resist the transfer of heat. Another study by Hawks (2005) demonstrated that, each type of insulation has a different R-value for each inch of thickness. This means that, 3 inches of fiberglass will have a value of about R-10 while 3 inches of foam board has a value of about R-15.

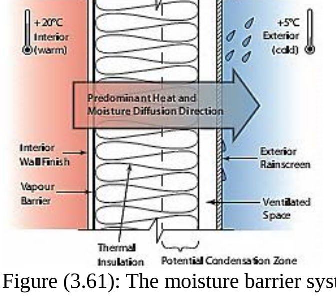


Figure (3.61): The moisture barrier system
Source: (Robertson, 2009)

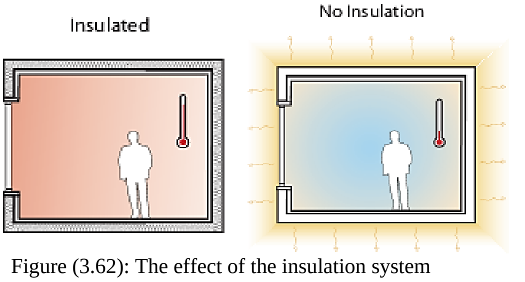


Figure (3.62): The effect of the insulation system
Source: (Robertson, 2009)

Ideally, insulation should be kept separate from the internal environment, as some types of insulation collect dust and can add particulates to the air (Taiao, 2008). According to the study done by Robertson (2009) classification of insulation is not straightforward, as there are several systems to differentiate between materials. This study concluded that, materials can be categorized as organic or inorganic, renewable or non-renewable, or they can be listed by consistency, such as foam, rigid, wool or loose. Although insulation can be made from variety of materials, it also comes in different types and different characteristics, among those types are:

- Rolls or blankets: They are flexible products made from mineral fibers, such as fiberglass and rock wool. They are available in width suited to standard spacing of wall studs, it is agreed that 2x4 walls can hold R-13 or R-15 batts, while 2x6 walls can have R-19 or R-21 products (U.S. Department of Energy, 2009).
- Loose-fill insulation: It is usually made of fiberglass, rock wool, or cellulose in the form of loose fibers or fiber pellets. It should be blown into spaces using special pneumatic equipment. Thus, the loose-fill insulation is well suited for places where it is difficult to install other types of insulation (Robertson, 2009).
- Rigid foam insulation: Foam insulation typically is more expensive than fiber insulation. But, it’s very effective in buildings with space limitations and where higher R-values are needed (Robertson, 2009). Foam insulation R-values range from R-4 to R-6.5 per inch of thickness, which is up to 2 times greater than most other insulating materials of the same thickness (U.S. Department of Energy, 2009).
- Foam in-place insulation: This type can be blown into walls and reduces air leakage, if blown into cracks, such as around windows and door frames (U.S. Department of Energy, 2009).
- Plastic foam insulation: Plastic foam insulation is a moisture and air barrier, unlike fibrous insulation, it is like polystyrene and polyurethane,. It is available in 4-foot by 8-foot or 2-foot by 8-foot sheets of various thicknesses. Foam sheets can be used to insulate masonry walls o-r as insulated sheeting on frame walls (Hawks, 2005).
- Sprayed polyurethane: It is stated by Hawks (2005) that, it is sometimes used to insulate walls, foundations, or roofs. It is costly to install, but worth its higher price when adhesion, moisture-resistance, air-sealing ability and structural strength are important. Sprayed polyurethane insulation is usually applied by professional crews with truck-mounted equipment.

To sum up, it can be said that, insulation is an essential component of passive design. As it is widely known that, the amount of heat flowing through a building depends mainly on the skin's thermal mass and thermal transmittance(Climate and Comfort, 2005). This means that, insulating materials have direct impacts on thermal transmittance. Moreover, they are used on roofs, external walls and ground floor slabs of buildings to ensure protection against outdoor conditions and minimizing heat loss and gain.

3.4.2.6. Shading Devices:

Shading is the first line of defense, reducing the ingress of solar gain, as it prevents solar radiation from falling directly onto occupants (Baker & Steemers, 2005). It is worth mentioning, that, the main purpose of shading is to reduce the amount of radiant energy passing into the rooms, this means that it reduces the ineffective temperature and glare (Taiao, 2008). Ideally the effective shading systems should reduce daylighting levels all year round, as it can shade summer sun and admit winter sun, see figure (3.63) (Baker & Steemers, 2005).

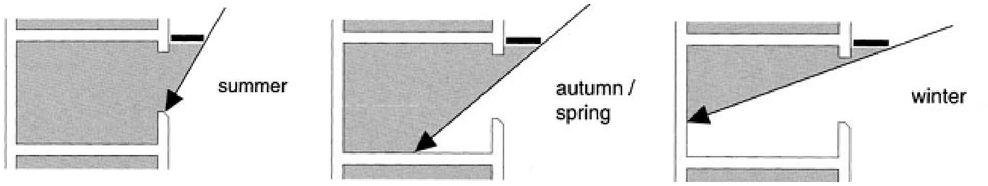


Figure (3.63): The effect of the shading device all year round
Source: (Baker & Steemers, 2005)

There are numerous types of shading devices can be used to shade and redirect light into a space where it is useful (Robertson, 2009). Among those types are: movable devices, fixed shading devices, eaves, louvers, light shelves, as well as sunshades, as shown in figure (3.64). Many of those shading devices and shading design strategies were discussed below:

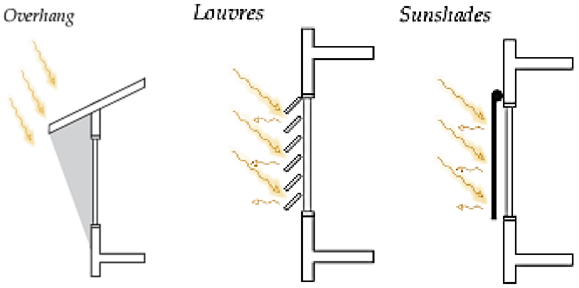


Figure (3.64): The different type of shading devices
Source: (Robertson, 2009)

- **<u>Overhangs and Side Fins:</u>**

The most common form of shades in hot climates is an exterior fixed horizontal overhang. These fixed devices can be located inside or outside the building; they mainly used to control direct or indirect solar gain with little effects on views (Taiao, 2008). The advantage of using fixed window protection is generally limited to windows facing north and south, as shown in figure (3.65) (Technology Fact Sheet, 2000). As it is widely known that, the fixed shades often compromise daylighting during times of lower sky luminance. They used not only to allow low-angle winter sun, but also block high-angle summer radiation (Baker & Steemers, 2005). On the other hand, for windows facing east or west, other devices must be used to avoid low angled sun (Autodesk, 2011). Thus, vertical projections or sidefins offer a way to shade those windows (Taiao, 2008). It is important to mention that, shading west façades is critical to reduce peak cooling loads (Technology Fact Sheet, 2000). In short, it can be said that, a wide range of shading devices can be used, including overhangs on south façades, fins on east and west façades in order to provide cost effective, functionally effective solar control, as shown in figure (3.66) (Technology Fact Sheet, 2000).

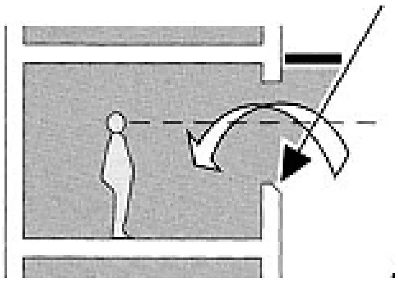


Figure (3.65): The fixed overhang
Source: (Baker & Steemers, 2005)

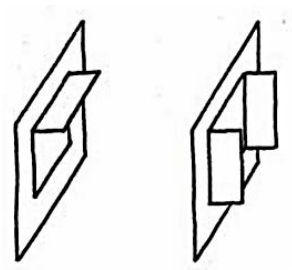


Figure (3.66): Types of overhangs
Source: (Taiao, 2008)

It is preferred to use overhangs for high summer sun, while sidefins for low-angle sun in the morning and afternoon (Taiao, 2008). As an example, the proper size of shading elements can be calculated in the study done by Nielsen (2002) which investigated roughly appropriate overhang dimension by using the following formula. Actually, the efficient overhang should provide shade well into summer and full sun through the coldest part of winter. To select the proper size of the shading elements, as own in figure (3.67). The overhang width (W) can be calculated by selecting the shade line factor (SLF) from the table below table (3.6) and inserting in the formula:

W (overhang dimension) = H / SLF

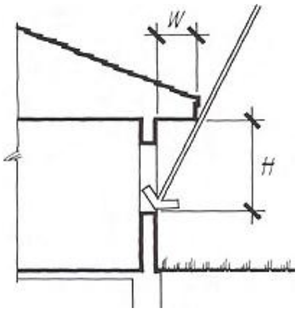
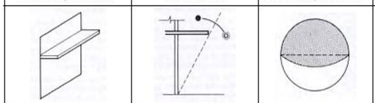
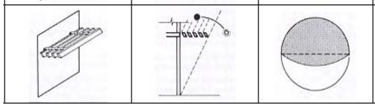
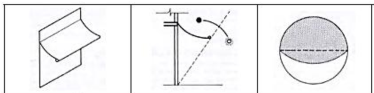
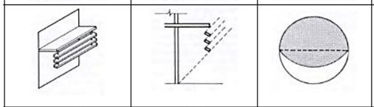
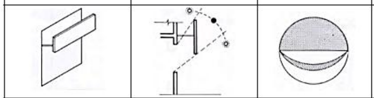
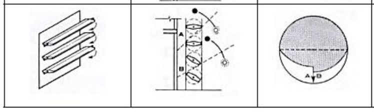


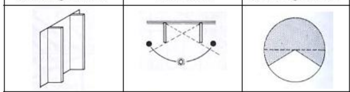
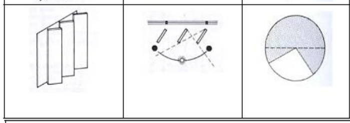
Figure (3.67): The proper size of shading elements
Source: (Nielsen, 2002)

Shade Line Factors (SLF) for Phoenix region (latitude 33.5°)	
Window Faces	**Shade Line Factor**
East	0.8
Southeast	1.4
South	3.6
Southwest	1.4
West	0.8

Table (3.6): The shade line factor
Source: (Nielsen, 2002)

To sum up, it can be said that, exterior shading devices are the most effective for creating tempered connections and transitions for indoor/outdoor spaces. The following table (3.7) illustrations show some of the basic shading devices, which are classified as horizontal, vertical and eggcrate types. The dash lines shown in the side view diagram indicated the sun angle at the time of 100% shading. A shading mask for each device is also shown with 100% shading indicated by the grey area. A shading mask is the shadow cast by a building projection such as an overhang and is helpful in determining the effectiveness of a shading device for a given orientation (Brown & Mark, 2001).

Horizontal Types			
Shading Device	Side View	Shading Masks	Comments
			Straight overhangs are most effective on southern exposure.
			Louvers parallel to wall allows hot air to escape and are most effective on southern exposure.
			Awnings are fully adjustable for seasonal conditions and most effective on southern exposure.
			Horizontal louvers hung from solid overhangs cuts out the lower rays of the sun. Effective on south, east and west exposures.
			Vertical strip parallel to wall cuts out the lower rays of the sun. Effective on south, east and west exposures.
			Rotating horizontal louvers are adjustable for daily and seasonal conditions. Effective on south, east and west exposures.

Vertical Types			
Shading Device	Plan View	Shading Masks	Comments
			Vertical fins are most effective on the near-east, near-west and north exposures.
			Slanted vertical fins are most effective on east and west exposures. Slant toward north and separation from wall minimizes heat transmission.

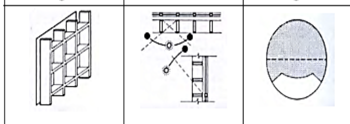
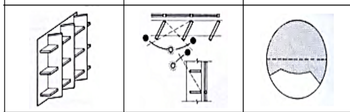
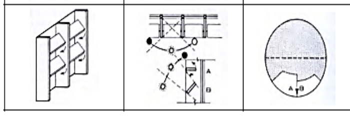
Eggcrate Types			
Shading Device	Plan & Side View	Shading Masks	Comments
			Eggcrate types are combinations of horizontal and vertical types. Most effective in hot climates on east and west exposures.
			Eggcrate with slanted vertical fins (slant toward north). Most effective in hot climates on east and west exposures.
			Eggcrate with rotating horizontal louvers. Most effective in hot climates on east and west exposures.

Table (3.7): Basic shading devices are classified as horizontal, vertical and eggcrate types
Source: (Brown & Mark, 2001)

- **<u>Fixed louvers:</u>**

The design of the louver arrangement needs to be optimized to eliminate undesirable sunlight. This may be affected by the depth of the louvers and often determined by the product used, as well as the spacing and orientation of the louver blades (Taiao, 2008). As described previously, according to the sun angle, horizontal louvers are best used on the northern facade, where the sun tends to be higher, while the western and eastern facades would benefit from vertical louvers, as shown in figure (3.68) (Technology Fact Sheet, 2000). The louvers can also be automated inside or outside the building for maximum efficiency, as shown in figure (3.67). Although, the exterior louvers are the best performing option in reducing heat gains, it can be difficult to maintain and also obscure the external views. On the other hand, the internal shading slows heat down, reducing peak loads, but still allows the majority of the sun's heat into the space (Baker & Steemers, 2005). To sum up, it can be said that, the horizontal louvers are best at blocking the high daytime sun, while vertical louvers block low-angle sun and are best suited to east and especially western facades (Taiao, 2008).

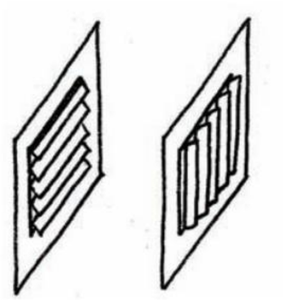


Figure (3.68): Horizontal and vertical louvers
Source: (Taiao, 2008)

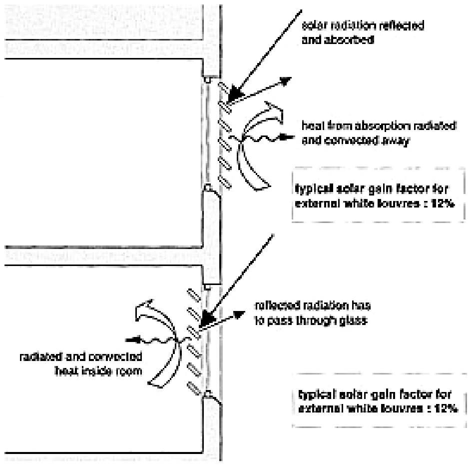


Figure (3.69): Internal and external louvers
Source :(Baker & Steemers, 2005)

- **<u>Light Shelves:</u>**

It is possible to improve the behavior of large window systems, by means of the use of passive devices like horizontal light shelves, to reach higher levels of natural light utilization (Rungta & Singh, 2011). Light shelves block direct sun while reflecting daylight off the room's ceiling deep into the space. This means that, they are light reflecting overhangs that reflect direct sunlight onto the ceiling for deeper and more uniform distribution in the interior spaces, as shown in figure (3.70) (Taiao, 2008). Add to that, it increases daylight illuminance levels at a distance of even 15 to 30 feet from the window (Rungta & Singh, 2011). Light shelves are located above vision glazing, up to and slightly above eye level, but below the high glazing above (Taiao, 2008). Generally, horizontal overhangs are placed above eye level in a window dividing the window into two horizontal layers, while the light shelf splits the window with one-third of glazing above and two-thirds below, as shown in figure (3.2) (Rungta & Singh, 2011). They may be positioned inside or outside or both as shown in figure (3.71). The main goal of it to save lighting energy, reduce glare and provide useful shading (Robertson, 2009).

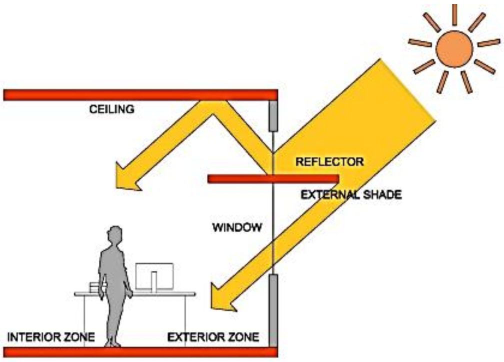


Figure (3.70): Components of light shelves
Source: (Rungta & Singh, 2011)

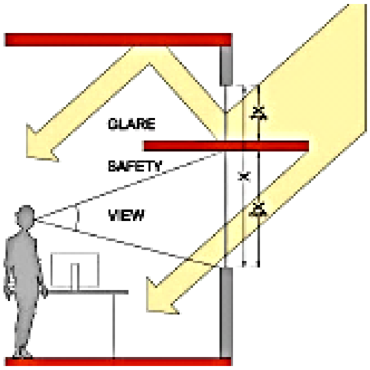


Figure (3.71): Design considerations for light shelves
Source: (Rungta & Singh, 2011)

- **<u>Double Skin Facades:</u>**

In recent decade, double skin facades have been implemented to harness benefits of increased energy efficiency, acoustic isolation and access to natural ventilation (Architecture week design, 2013). For best results, a double skin facade should be on the northern facade of the building so that it receives as much heat from the sun as possible to drive the natural ventilation. It is important to mention that, this system can be expensive, as it is considered a relatively new technology in its modern applications and systems integration. The double skin facade presents a unique condition compared to conventional single-skin facades, as it is a fully integrated system, as shown in figure (3.72) (Architecture week design, 2013). They are essentially doubling the glazing requirements for that face of the building, although they have the benefit of having other passive design strategies, such as light shelves or natural ventilation. In short, this system allows the occupants to benefit from the flexibility of movable shading, while preventing solar gains from re-radiating back into the occupied space (Taiao, 2008).

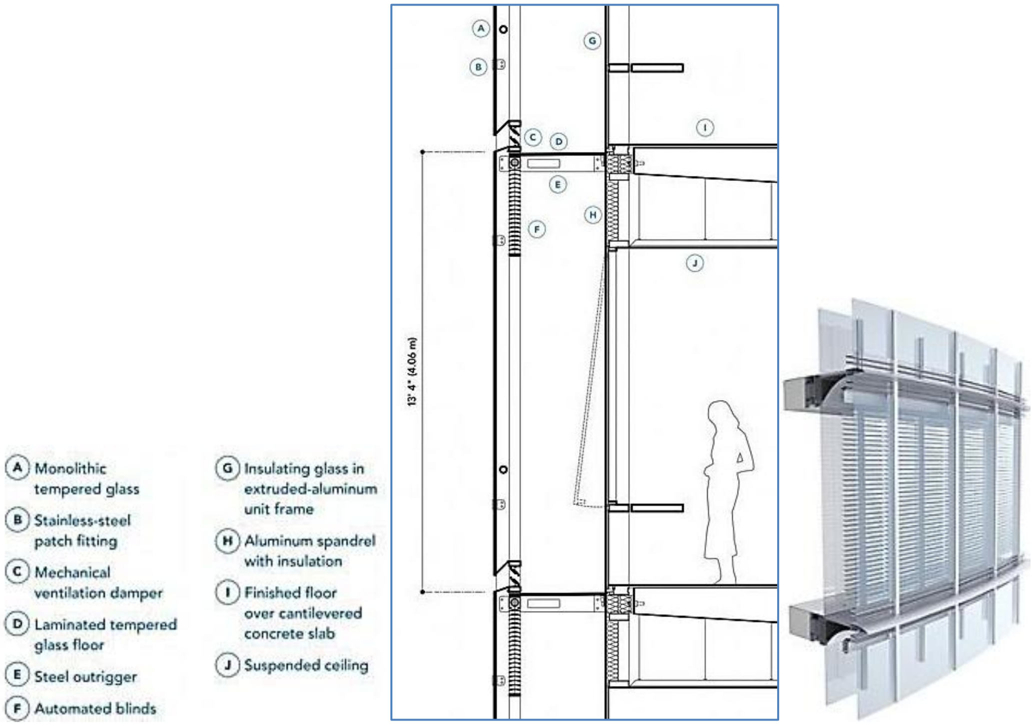


Figure (3.72): Double skin facades
Source: (Architecture week design, 2013)

3.4.2.7. <u>Natural Ventilation System</u>:

In hot climates, natural ventilation strategies can supply fully fresh air with no mechanical air conditioning systems (Taiao, 2008). This consequently reduces the building's energy use for heating and cooling systems (Autodesk, 2011). It is worth mentioning that, natural ventilation usually uses natural outside air movements and pressure differences to both passively cool and ventilate the building (Baker & Steemers, 2005). Successful natural ventilation is determined by having high thermal comfort and adequate fresh air for the ventilated spaces, as the studies have linked increased fresh air rates with increased occupant health (Taiao, 2008). It appears that in many cases occupants are much happier and healthier in naturally ventilated buildings (Baker & Steemers, 2005).

The study by Baker & Steemers (2005) argued that, the natural ventilation strategies are not soft options for designers and have much more impact on the architecture of the buildings. The study concluded that, a detailed understanding of the opportunities for using wind driven ventilation should come from the site analysis undertaken before the design phase starts. To some extent these parameters are influenced by site conditions such as other buildings, vegetation, landscape features, as well as wind direction and speed. Then, the building needs to be designed to maximize the potential of that site conditions, by predicting exactly how air will move through a building. Openings and airflows need to be sufficient to provide the required level of ventilation, cooling and fresh air. From another perspective, the natural ventilation strategies can be generated through the pressure differences and the temperature conditions across or within the building (Taiao, 2008). Hence, the pressure differences over the building surfaces is due to the change in momentum when the air is deflected or its speed is reduced (Autodesk, 2011). As it is widely known that, the positive pressures are on the windward side and the negative pressures are on the leeward side, as shown in figure (3.73). Unless the envelope is completely impervious, this will result in a flow of air into the windward side, across the building and out from the leeward side (Baker & Steemers, 2005).

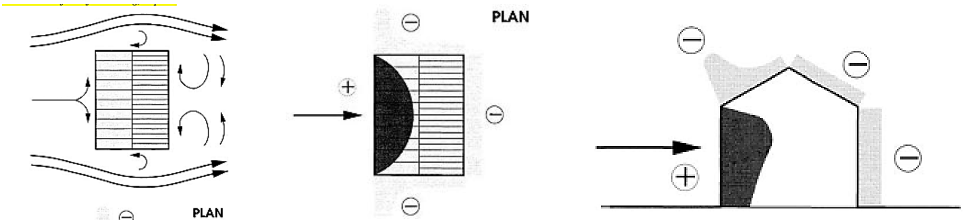


Figure (3.73): Distribution of wind-induced pressure over the surface of a building
Source: (Baker & Steemers, 2005)

To sum up, it can be said that, wind ventilation is a kind of passive ventilation, using the force of the wind or local air pressure differences in order to pull air through the building (Baker & Steemers, 2005). Successful wind ventilation is determined by having high thermal comfort and adequate fresh air for the ventilated spaces, while having little or no energy use for active HVAC cooling and ventilation (Taiao, 2008). In general, the keys to good wind ventilation design include operable windows, building orientation massing, as well as sizing and placing openings appropriately for the climate (Autodesk, 2011). Design strategies according to those aspects will be discussed in details in the following part:

- **<u>Building Form:</u>**

The most suitable shape and layout of naturally ventilated buildings are very similar to that discussed for daylighting (Baker & Steemers, 2005). It was proved in the study done by Taiao (2008) that, the natural ventilation strategy will only be effective up to a maximum distance of around 15 meters over an open plan layout with good cross flow.

In addition to that, using narrow building shapes will also increase natural ventilation inside the building as opposed to deep buildings, as shown in figure (3.74) (Donnelly, 2010). On the other hand, the study by Taiao (2008) also concluded the ventilation guidelines for room dimensions. It is agreed that, for two-sided ventilation the room width (w) should be around five times the room height (h), while for one sided venting, (w) should be around 2½ times (h), as shown in figure (3.75).

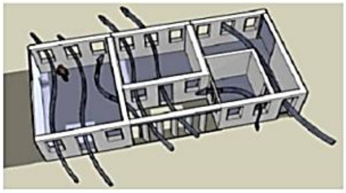


Figure (3.74): Narrow building help in cross ventilation
Source: (Stouter, 2010)

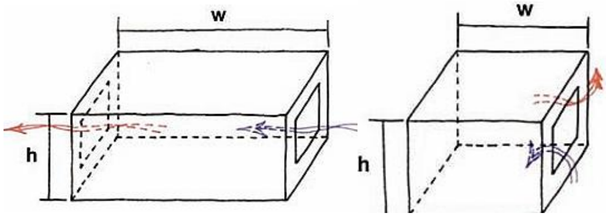


Figure (3.75): Ventilation guidelines for room dimensions
Source: (Taiao, 2008)

- **<u>Openings:</u>**

The second simple design strategy is that, openings should be widely distributed over individual surfaces and different façades of the building envelope. This ensures that the openings will be at different pressures and that the subsequent air flows will be well distributed in the building (Baker & Steemers, 2005). The easiest method of bringing outdoor air into a room is to open the window (Taiao, 2008). So when there is difference between outdoor and indoor temperature, ventilation can be accomplished by natural means. This means that, windows should be well-located according to the prevailing winds, so that it could help in bringing the fresh air while removing warm air (Robertson, 2009).

It is quite important to determine the style and operability of the window, in order to achieve the maximum levels of ventilation. For example hinged or pivoting windows that open to at least 90 degrees can offer the greatest potential for ventilation, while awning or casement windows opened by short winders provide the least potential (Autodesk, 2011). On the other hand, window placement can also influence the rate of ventilation inside the building. The height and opening direction will affect the degree to which a window can take advantage of prevailing winds (Taiao, 2008). To sum up, it can be said that, height and placement will direct the air to where it is needed, while choosing windows that either open inward, outward or slide will affect the amount of air that can be captured. This is consequently has an impact on occupant comfort through appropriate access to fresh air (Robertson, 2009).

Cross ventilation is generally the most effective form of wind ventilation (Autodesk, 2011). It occurs between windows on different exterior wall elevations. According to a study done by Astrand (1996) which showed that, it is necessary to place openings opposite to each other to allow good cross ventilation, which can improve indoor climate significantly. Cross ventilation can be very effective for wind-generated pressure differences with useful depth up to 9m, or at least three times floor to ceiling height, while if back-to-back, 18m zones can also be cross ventilated (Robertson, 2009). This means that, windows should be placed where it is possible to achieve either stack effect or cross ventilation. In general, it is preferred not to place openings exactly across from each other in a space, as shown in figure (3.76) (Astrand, 1996). It is preferred to place inlets low in the room and outlets high in the room, this can cool spaces more effectively, because they leverage the natural convection of air. This may be extended to the reason of cooler air sinks lower, while hot air rises, this means that, locating the opening down low helps to push cooler air through the space, while locating the exhaust up high helps pull warmer air out of the space (Autodesk, 2011). On the other hand, cross ventilation can be increased by having large openings on both the windward (positive pressure zone) and leeward faces (negative pressure zone) of the building, as shown in figure (3.77) (Donnelly, 2010).

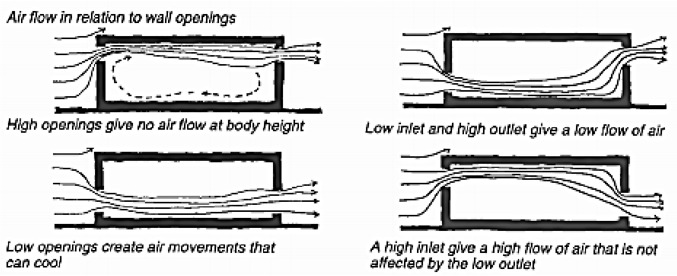


Figure (3.76): Air flow in relation to wall openings
Source: (Astrand, 1996)

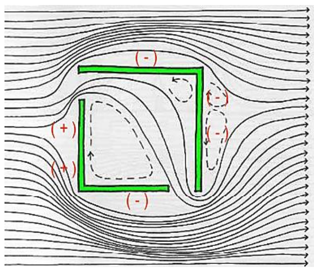


Figure (3.77): Windward and leeward faces
Source: (Donnelly, 2010)

It is important to mention that, not all parts of buildings can be oriented for cross ventilation (Autodesk, 2011). But wind can be steered by architectural features, these features can range from casement windows, wing walls, fences, or even planted vegetation. Actually, these features can be used to scoop air into the room (Donnelly, 2010). A good example of those features is the wing walls, as the study by Brown &Mark (2001) explained that, wing walls are especially effective for sites with low outdoor air velocity and variable wind directions. It can be defined as a project outward next to a window, so that even a slight breeze against the wall creates a high pressure zone on one side and low on the other. The pressure differential draws outdoor air in through one open window and out the adjacent one, as shown in figure (3.78).

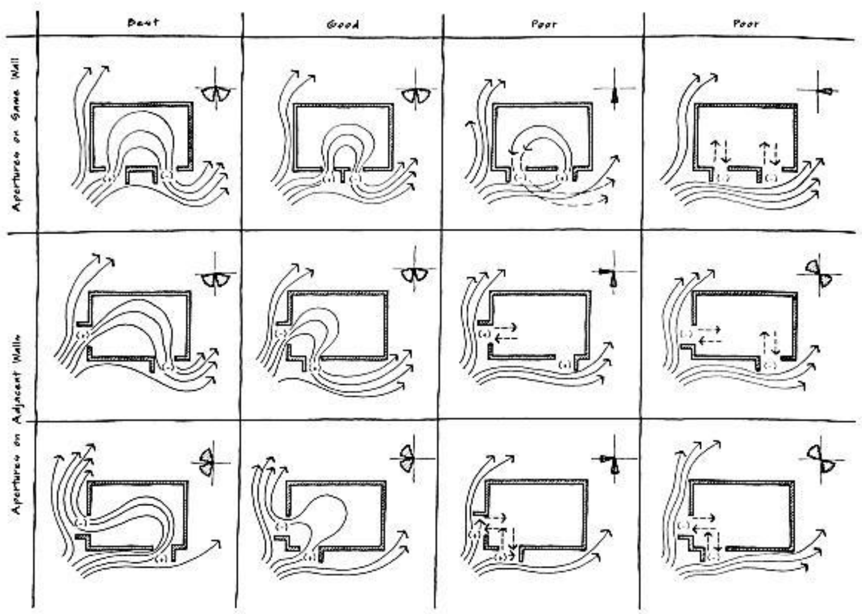


Figure (3.78): Different wing walls of better and worse effectiveness on same wall and adjacent walls
Source: (Brown &Mark, 2001)

In short, the designer should have not only provide openings but also, locate them correctly to work properly. The location and distances between openings should enhance single sided or cross natural ventilation, as shown in figure (3.79) (Stouter, 2008). On the other side, the design should also provide each room with 2 exterior walls, with many windows or vent in order to enhance indoor ventilation (Donnelly, 2010).

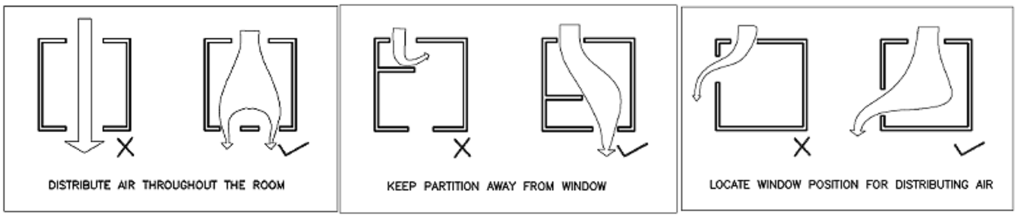


Figure (3.79): The effective location and distances between openings
Source: (Stouter, 2008)

- **<u>Stack Ventilation and Bernoulli's Principle:</u>**

Stack ventilation and Bernoulli's principle are two kinds of passive ventilation that use air pressure differences due to height to pull air through the building (Autodesk, 2011). Stack effect is achieved by placing some windows at lower levels in the basement, while others are placed at higher levels on the top floor, as shown in figure (3.80). The lighter, warm air is displaced by the heavier, cooler air entering the building, leading to natural ventilation, as shown in figure (3.81) (Autodesk, 2011). It is agreed according to Baker & Steemers (2005) that, the greater the temperature difference, the stronger the air flow generated. This kind of natural ventilation is appropriate for summer months, as it may also cool the interior space, reducing the need for electric fans or pumps traditionally used for cooling, this in turn can lead to lower energy consumption.

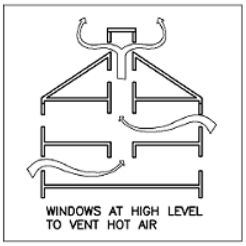


Figure (3.80): The Stack effect
Source: (Robertson, 2009)

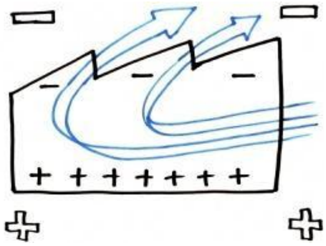


Figure (3.81): Lower air pressures at higher heights can passively pull air
Source: (Autodesk, 2011)

On the other hand, Bernoulli's principle uses wind speed differences to move air. It is a general principle of fluid dynamics, saying that the faster air moves, the lower its pressure. Architecturally speaking that, the outdoor air farther from the ground is the less obstructed, so it moves faster than lower air and thus has lower pressure. This lower pressure can help suck fresh air through the building (Robertson, 2009). The advantage of Bernoulli’s principle over the stack effect is that, it multiplies the effectiveness of wind ventilation. The advantage of stack ventilation over Bernoulli's principle is that, it does not need wind: it works just as well on still, breezeless days when it may be most needed (Autodesk, 2011). A good example is the special-designed wind cowls in the BedZED development, which use the faster winds above the rooftops for passive ventilation, as shown in figure (3.82) (Lazarus, 2002).

Figure (3.82): Special wind cowls in the BedZED development
Source: (Lazarus, 2002)

- **Atriums:**

The last design strategy which can also affect the natural ventilation inside the building is using the internal atrium. It is worth mentioning, that one of the many functions of an atrium is to provide natural ventilation to areas that are difficult to ventilate from the perimeter (Baker & Steemers, 2005). It is argued in the study by Taiao (2008) that, the atrium's height allows a temperature gradient to develop, which then creates air movement through the stack effect. The study also explained that, the warm air rising in the atrium draws cool air into the rooms at the perimeter. Others argued that, this allows natural ventilation access to a larger proportion of a building's floor area when its footprint may have been otherwise unsuitable for passive solutions (Robertson, 2009). In general, the study by Taiao (2008) also explained that, the floor area of the atrium should be around 2 per cent of the area which is used to service. Figure (3.83) shows a typical natural ventilation strategy with an internal atrium.

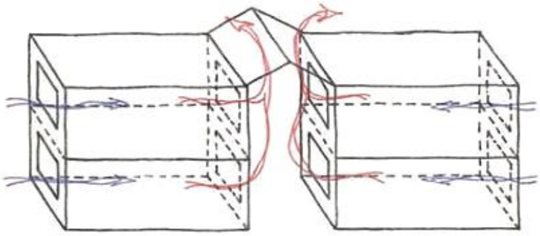


Figure (3.83): A typical natural ventilation strategy with an internal atrium.
Source: (Taiao, 2008)

3.5. Energy Distribution:

Beside the efforts in reducing CO_2 emissions through applying energy consumption techniques, it is quite important to think in the energy distribution systems (Davoli et al., 2012). In the study done by McGeough et al. (2004) that investigated the effectiveness of the energy system in the last decades, showed that most electrical energy that reaches our cities is generated at central power plants. Those power plants are often located hundreds of miles away from our urban districts. The study indicated that, many of those central power plants deliver only about 30% of their input fuel energy to end users, while the remaining 70% of the fuel energy is lost at the plant and in transmission. These losses are decreased if service runs are as short as possible, in particular if zones of the buildings are located close to one another and close to the main generation sources (California Energy Commission, 2013). Accordingly, today´s challenges in power transmission ask for flexible and effective technical solutions for economic power transmission over very long distances and also a trusted method to connect grids of different frequencies (Baker & Steemers, 2005). On the other hand, another study by Davoli et al. (2012) asked for proposing innovative solutions for electrical distribution grid, with the objective to improve the integration of power generated from renewable energy sources besides the power generated from the conventional sources. It is now widely recognized that, sustainable infrastructure expansion is therefore a priority for the countries in order to meet their needs for better energy efficiency and sustainable power generation (Baker & Steemers, 2005). As, this strategy can reduce energy uses and GHG emissions through efficient managements of the distribution of energy (McGeough et al., 2004).

3.5.1. <u>Transmission and Distribution Systems:</u>

The traditional electrical system is characterized by a flow of energy from few production points to the consumers, it is quite important to deliver the energy in an efficient way. It is worth mentioning, that the production is carried out by large power plants that generate electrical energy from various sources such as coal, oil, nuclear and large renewables (California Energy Commission, 2013). But as it mentioned in the study done by McGeough et al. (2004) that, those plants are usually located away from urban areas for technical and environmental reasons. The link between those production points and the users is described by an electrical interconnection infrastructure, called the grid. This grid can be classified in three main parts which are: Transmission, Sub-Transmission and Distribution grid, as shown in see figure (3.84) (Davoli et al., 2012).

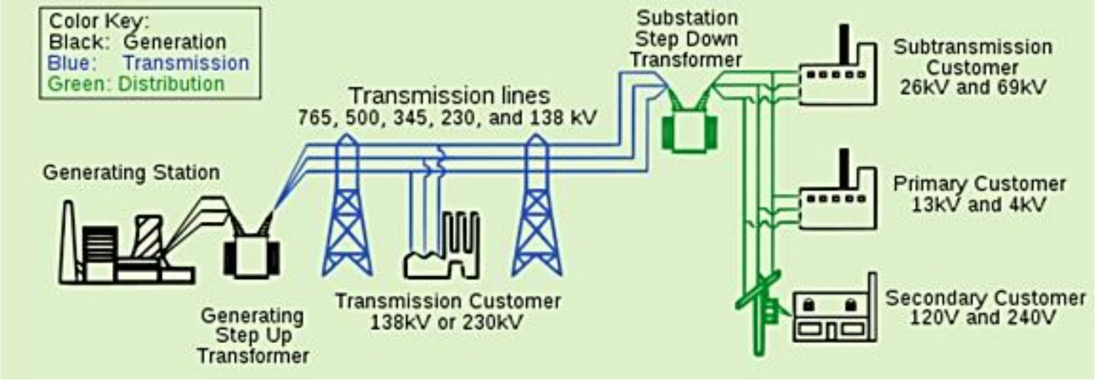


Figure (3.84): Layout of a traditional grid system
Source :(Davoli et al., 2012)

Traditionally, both the transmission and distribution systems are one-way channels that delivered electricity from the point of generation to the point of consumption (Davoli et al., 2012). There are numerous differences that must be determined in order to know the three phases of the traditional electrical system. Among those differences that, transmission lines which generally run substation to substation at very high voltage levels (World Energy Council, 2012). While, the distribution grid carries medium and low voltage electricity to medium and small consumer centers. It is worthwhile to be mentioned, according to the study by Davoli et al. (2012) that, the distribution lines are the ones that run through a neighborhood serving individual customers along the way. This means that the voltage is stepped down through the use of transformers to the customer's utilization voltage, which serves every house, industry, road and traffic light systems (World Energy Council, 2012). On the other side, the intermediate phase is an optional phase, as sub-transmission grid can be included in the distribution networks. It is quite important to define it as a high voltage infrastructure that carries electricity from the transmission grid to the distribution grid. Sometimes, sub-transmission networks are included in distribution networks (Davoli et al., 2012). To sum up, it can be said that the power transmission deals with high tensions from the generators to the last transformer station, while the power distributions deals with low tension from the last transformer station to the costumer. This means that the power transmission is before the entry points to the cities, while the power distribution is localized in towns or cities (California Energy Commission, 2013).

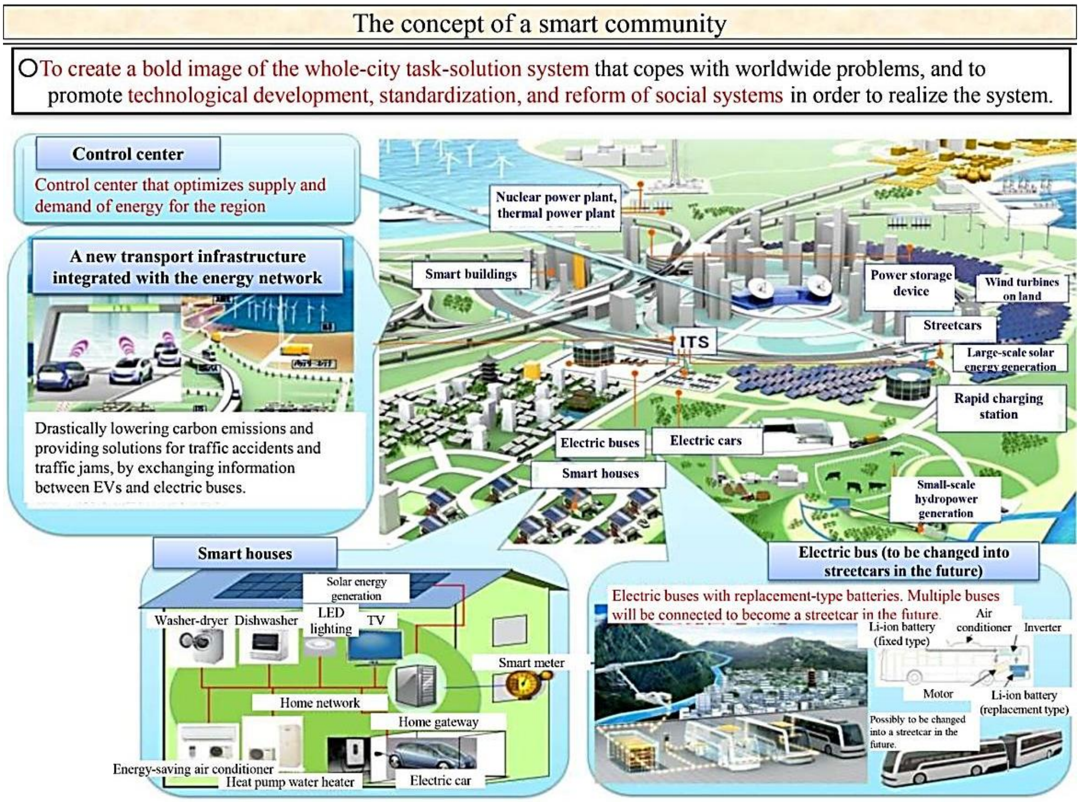
Losses in transmission and distribution networks represent the biggest problem in any electrical system (Davoli et al., 2012). As mentioned before, that 75% of the losses occur within the electrical system itself, consequently this energy lose cannot be negligible (World Energy Council, 2012). It is stated by Davoli et al. (2012) that, losses include losses in transmission between the sources of supply and the points of distribution and also in the distribution to consumers. Another study demonstrated that, the loss in transmission cables accounts for losses of about 2.5 %, while the losses in transformers range between 1 % and 2 %, depending on the type and ratings of the transformer. So, saving just 1 % of the electrical energy produced by a power plant of 1000 megawatts means transmitting 10 MW more to consumers, with the same energy 1000- 2000 more homes can be supplied (International Electro-Technical Commission, 2007). Thus, there is a big need for new infrastructure for energy grids, to achieve the major revolution in the energy generation and distribution. Those intelligent grids are mainly the base of what is called smart communities. The main target from those communities is to improve the efficiency and performance of the global energy system and the supply chain (Schiller & Fassmann, 2010).

3.5.2. Smart Communities:

From a general point of view, developing countries and emerging economies are often categorized by high growth in electricity demand and high technical losses in a context of dense urban populations (Schiller & Fassmann, 2010). It is worthwhile to consider that, the smart grids can play an important role in the development of new electricity infrastructure in developing countries and emerging economies by enabling more efficient operation and lower costs (Cisco, 2013). From the other side, it was obvious that smart communities are the logical extension of smart grids from electrical systems to other types of infrastructure systems, which are ultimately expected to evolve in this direction (Schiller & Fassmann, 2010).

Thus, there is a big need to shift to this direction in order to achieve the overall efficiency of energy generation and distribution. Therefore, global policy makers have begun crafting roadmaps to increase energy efficiency by establishing the smart communities. The reason for promoting the establishment of smart communities lies under the fact that, the small and medium clients, which are the traditional energy customers, are increasingly becoming energy aware and participate actively in the energy market. This may also be extended to the big need in reducing the overall CO_2 emissions, which is directly reduced by increasing the amount of decentralized green energy generation (Japan Smart City, 2013). It is stated by Schiller & Fassmann (2010) that, all the energy grid operators pointed that, this megatrend translates into an urgent need for modernization of the energy distribution grid infrastructure which can balance between decentralization energy generation, storage and consumption. This consequently reduces the need for centralized communications and enables autonomous operations of increasingly smaller sections of the distribution grid (Davoli et al.,2012). The efficiency and viability of this innovative depend on the ability to combine smaller forms of electricity generation with energy management systems to balance out the load of all the users on the systems. These types of energy sources can be closer to the users, in comparison to the large centralized source and can improve the efficiency of the electric system by reducing grid losses (McGeough et al., 2004).

It is quite important to mention that, establishing smart communities is not simply a question of changing the outer appearance of urban areas, while it is all about bringing innovation to the lifestyles of the residents themselves (Japan Smart City, 2013). There are numerous aspects that can describe any smart community. Among those aspects that the community should integrate several energy supply and use systems within a given region in an attempt to optimize operation and allow for maximum integration of renewable energy resources from large-scale wind farm deployments to micro-scale rooftop photovoltaic and residential energy management systems (Schiller & Fassmann, 2010). Actually, there are large numbers of experimental projects are currently being carried out around the global in order to discover a core model for smart communities. Among those experiments, there is the Japan experience, which provide up to date information on four cities of Japan in order to create smarter cities, as shown in figure (3.85) (Japan Smart City, 2013).



Figure(3.85): Smart community conceptual model in Japan
Source: (Japan Smart City, 2013)

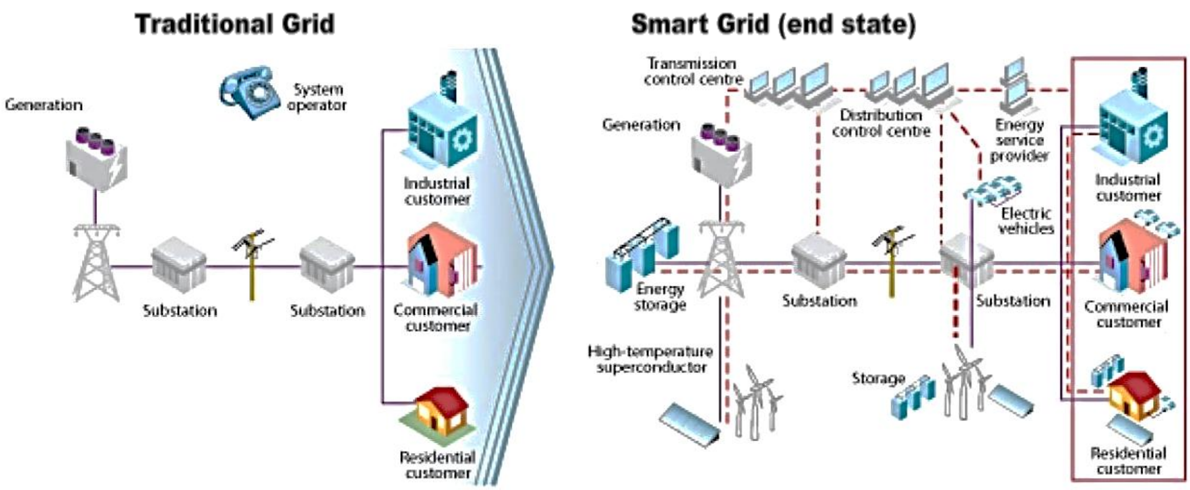
To sum up, it can be said that the design of smart communities is a new style of city providing sustainable growth and designed to encourage healthy economic activities that reduce the burden on the environment, while improving the quality of life of their residents (Japan Smart City, 2013). Many of these innovations were unthinkable in the past, such as the widespread of smart home, which can be used to recharge distribution of electric vehicles (Smart Grid.gov, 2013). In addition to, the transformation of today's power grid to an intelligent grid, this is called the smart grid. It is also worth mentioning that, this grid enables more efficient use of decentralized green energy generation and helps to significantly reduce the consumption of private, industrial and public consumers (Cisco, 2013). The goals of such integration through the use of smart grid, smart home and decentralized green energy generation will increase the sustainability, security and reliability. In addition to, some societal benefits such as job creation, better services and reduce capital investment (International Energy Agency, 2011).The following part discussed in details each component of the smart community such as:

3.5.2.1. <u>Smart Grid:</u>

According to the study by the International Energy Agency (2011) which showed that, the world's electricity systems currently face number of challenges, including ageing infrastructure, continued increase in the energy demand and the integration of variable renewable energy sources. In addition to the urgent need to improve the security of supply, as well as the need to lower carbon emissions. In consideration to these energy challenges, the smart grid technologies offer new ways not just to meet them, but also to develop a cleaner energy supply that is more energy efficient, more affordable and more sustainable (Burns, 2009 & International Energy Agency, 2011). On the other hand the study by Burn (2009) explained that, the integration between the current power infrastructures with smart grid technology is computerized based system, which provide the resident with more information to make intelligent decisions as well as make smarter energy choices. Thus, the development of smart grids is essential if the global community is aiming to achieve shared goals for energy security, economic growth and climate change mitigation (International Energy Agency, 2011).

The main issue in implementing the smart grid is the strong changing on the future electrical system, which changed due to the high integration of renewable energy sources (Davoli et al., 2012). This consequently led to the appearance of a new system of monitoring and controlling, which can be reached by improving the existing transmission and distribution grids through the introduction of smart devices (Cisco, 2013). It is worthwhile to consider that, the smart grid depends mainly on small remote systems not connected to a centralized electricity infrastructure, besides the advanced types of control and management technologies for the electrical grid (Davoli et al., 2012). It will enable real-time interactions among the devices, systems and operators, in order to contribute to a more efficient operational running of the overall system.

In short, the digital technology that allows for two-way communication between the utility and its customers and the sensing along the transmission lines is what makes the grid smart (SmartGrid.gov, 2013). It will act much more like an interactive web, with two-way communication, multi-directional power flow and closed-loop automation at its core (Robert, 2009). Also, it is an electricity network that uses distributed energy resources and advanced communication to deliver electricity more cost effectively, with lower impacts on the environment and with active involvement of the customers, as shown in figure (3.86) (Davoli et al., 2012). So, the term smart grid is a term that covers modernization of both the transmission and distribution grids, which marries information technology with the current electrical infrastructure (Burns, 2009).



Figure(3.86): Evolution from the traditional grid architecture to the smart grid
Source: (Davoli et al., 2012)

- **Smart grid Components:**

The smart grid consists of many technology areas, each area consisting of sets of individual technologies. The grid consists from generation through transmission and distribution to various types of electricity consumers (International Energy Agency, 2011). It is a system that combines different technologies ranging from communication networks to renewable energy power, in order to create energy infrastructures that are self-healing, predictive, adaptive, efficient and secure (Burns, 2009). A fully optimized electricity system will deploy all the technology areas, as shown in figure (3.87) (International Energy Agency, 2011).

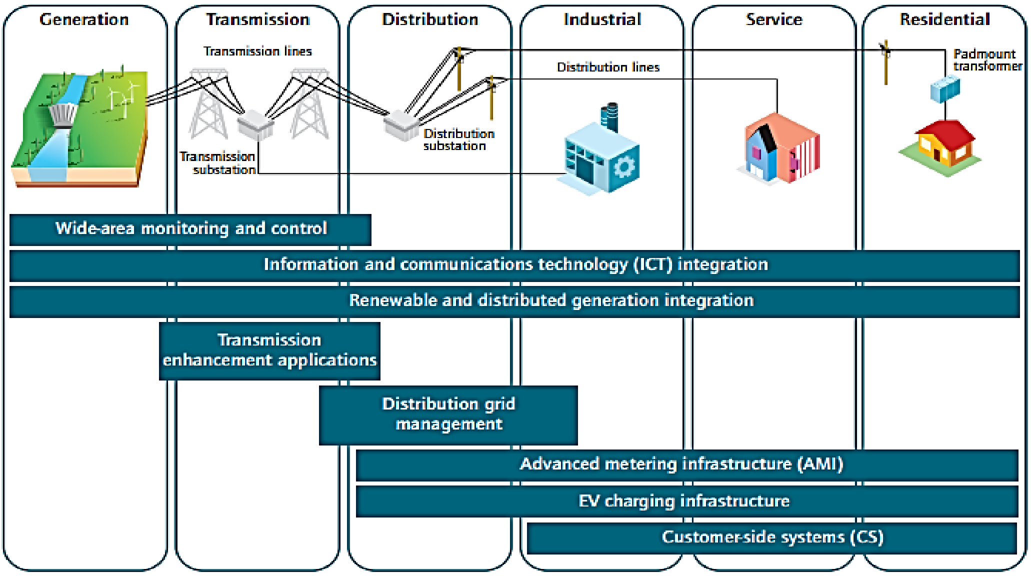


Figure (3.87): Smart grid components
Source: (International Energy Agency, 2011).

- **Smart Grid Benefits:**

The smart grid is a way to treat an energy infrastructure that needs to be upgraded or replaced (International Energy Agency, 2011). While the potential benefits of the smart grid are usually discussed in terms of economics, national security and renewable energy goals. It has the potential to help in saving money by managing the best times to purchase electricity. As, it empowers consumers to manage their energy usage and save money without compromising their lifestyle (National Institute of Standards and Technology, 2012). On the other hand, it's a way to address energy efficiency and to increase the awareness of the consumers about the connection between electricity use and the environment. Briefly, Smart grids are the way to get massive amounts of clean renewable energy resources with no greenhouse emissions into the system (Robert, 2009 & International Energy Agency, 2011).

Hence, the smart grid is a complex system of systems, serving the diverse needs of many stakeholders. Devices and systems developed independently by many different suppliers, operated by many different utilities and used by millions of customers, must work together. Achieving interoperability in such a massively scaled, distributed system requires architectural guidance (National Institute of Standards and Technology, 2012). This system equipped with sensors, two-way communications, advanced control devices and new visualization tools, which will give grid operators the tools they need to reduce distribution losses and improve asset utilization. Thereby reducing the generation capacity and production needed to serve a given load (California Energy Commission, 2013). It is actually the vision of efficiency and optimization across an entire energy ecosystem from energy production to usage, as shown in figure (3.88) (Burns, 2009). It represents an opportunity to move the energy industry into a new era of reliability, availability and efficiency, that will contribute to economic and environmental health (National Institute of Standards and Technology, 2012).

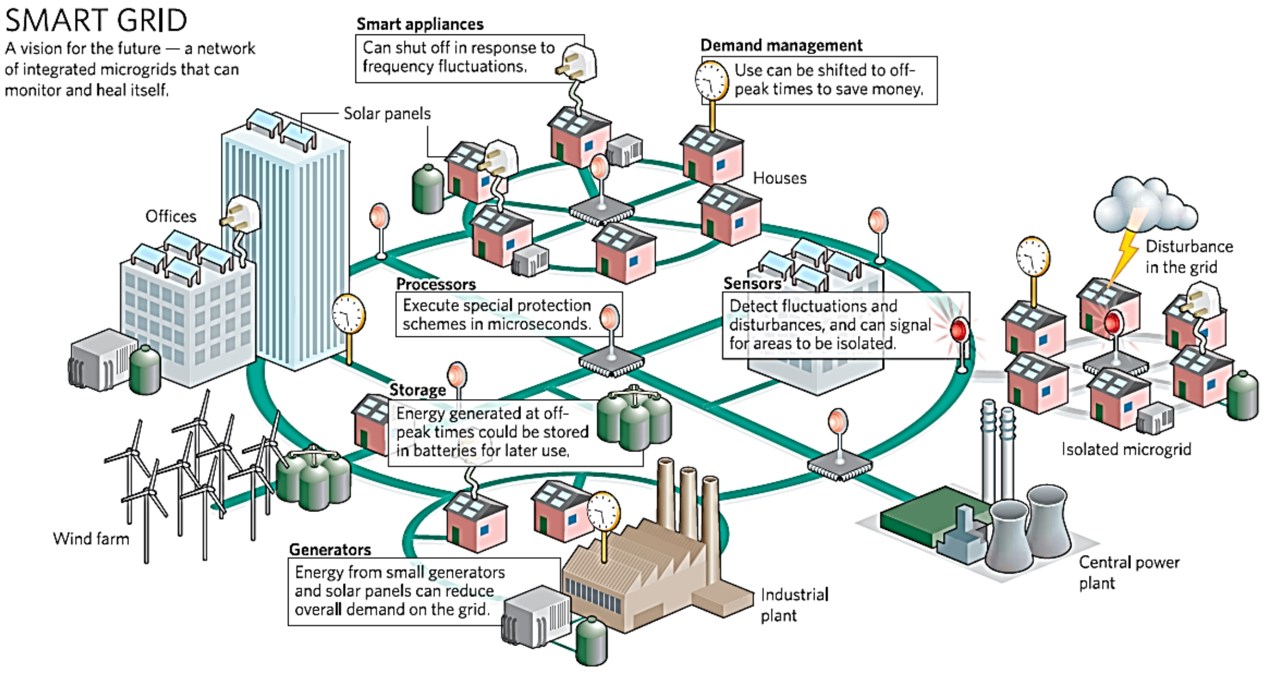


Figure (3.88):Example of the smart Grid
Source: (POWER-GEN Asia, 2013)

3.5.2.2. Smart Home:

According to the recent energy crises, the realization that energy resources are not inexhaustible and the general trend towards a cleaner environment have led to the development of many practices that aim for using energy as optimally as possible (Nikolaou et al, 2010). That lead to provide the market with new equipment, appliances and software in many cities across the nation. This equipment mainly can helped to emerge smart grid technologies with each other in order to save energy (Schiller & Fassmann, 2010). A key element that allows all of the emerging smart grid technologies to function together is the interactive relationship between the grid operators, utilities and residents. This refers that computerized controls in the resident's home and appliances should be set up, this mainly has materialized in the form of building energy management systems. This computerized system attempts to control all the energy consuming operations in the building, in order to minimize the energy use at times when the power grid is under stress from high demand. This may be extended to operate various parameters such as ventilation, lighting, indoor climate and other parameters. It is also expected that, the interrelations between those various parameters are taken into account, resulting in optimum operation (Nikolaou et al, 2010 & SmartGrid.gov, 2013).

It is also widely accepted the term smart or intelligent building is gaining popularity and this concept generated a good deal of the market during the last decade. Actually, smart term is referring to objects that can react correctly to unexpected circumstances by choosing among a set of possible actions. The main essential elements of any artificial smart building are the concept of self-correction or tolerance according to the surrounding circumstances (SmartGrid.gov, 2013). It is also worth mentioning that, any smart building initially consisted of outstations, which collected data and fed them to a central station. At the central station, a single data for all buildings is created and engineers are equipped with a powerful tool set to analyze data (Nikolaou et al, 2010). In addition to that, this provides a foundation for higher integration with a smart utility grid that manages energy supply and demand on a local or regional level, as shown in figure (3.89) (Johnson Controls, 2013).

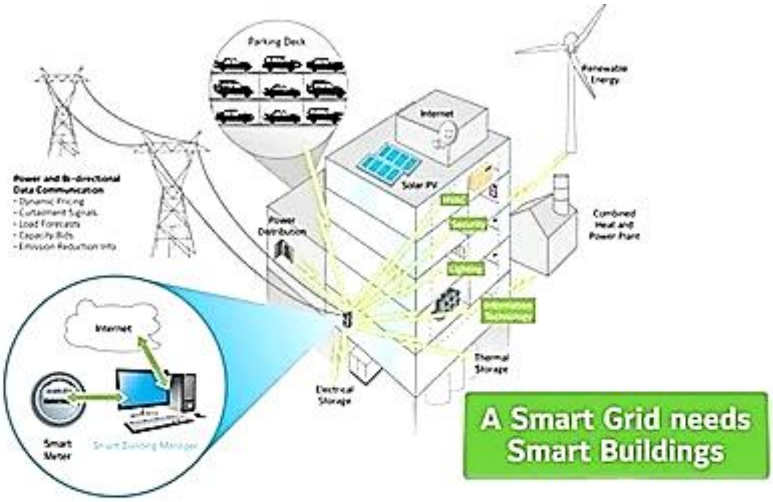


Figure (3.89): The smart building
Source: (Johnson Controls, 2013)

There are numerous aspects that any smart building consisting of, in order to interact well with the smart grid. Among those aspects are:

- Smart Meters and Home Energy Management Systems: Smart meters provide the smart grid interface between the resident and its energy provider. It should be installed in the place of the old, mechanical meter. These meters operate digitally and allow for automated and complex transfers of information between home and its energy provider. It is also worth mentioning that, smart meters also provide utilities with greater information about how much electricity is being used throughout their service areas. On the other hand, an energy management system also can allow the residents to choose settings that allow specific appliances and equipment to turn off automatically when large demand threaten. This has consequently helped to balance the energy load in the area and preventing blackouts (National Institute of Standards and Technology, 2012 & SmartGrid.gov, 2013).

- Smart Appliances: In the smart home, many of the appliances will be networked together, allowing the resident to access and operate them through the energy management system (Nikolaou et al, 2010). Those smart appliances will also be able to respond to the signals from the resident's energy provider to avoid using energy during times of peak demand. For instance, those appliances might defer running until off-peak hours, in order to reduce the load on the power grid. The most well-known types of smart appliances are the plug-in electric vehicle, the smart air conditioner as well as the smart refrigerator (SmartGrid.gov, 2013).

- Home Power Generation: As consumers move towards home energy generation systems, the interactive capacity of the smart grid will become more and more important (National Institute of Standards and Technology, 2012). Those home generation resources such as local rooftop solar electric systems, small hydropower and small wind turbines are now widely available all over the world. They allow the homeowners to keep the lights on even when there is no power coming from the utility. In general, the smart grid will help to effectively connect all these mini-power generating systems to the grid, to provide data about their operations to utilities and owners (SmartGrid.gov, 2013).

3.5.2.3. Distributed Energy Resources:

The last component in the smart grid is the distributed energy resources, which include distributed generation technologies, combined heating and power and district energy systems, as well as an energy efficiency mechanisms grid. There are numerous types of distributed generation technologies that can be used in order to produce electricity at or near the point-of-use. Among those types are reciprocating engines, gas turbines and micro-turbines, fuel cells, as well as various renewable technologies which include small wind, mini-hydro and solar photovoltaic panels (SmartGrid.gov, 2013 & McGeough et al., 2004). All of those technologies will be discussed in details in the part of energy generation. On the other side, the study by the National Institute of Standards and Technology (2012) also showed that, the new requirements for the power generation may include controls for greenhouse gas emissions and provision of storage to manage the variability of renewable generation. Actually, these systems can be used to relieve overloading of the main power grid during peak use demands. In addition to the power generation source, a distributed generation system can include a local-area distribution system or micro-grid, in order to provide electricity to more than one nearby facility and interconnection equipment that enables the system to share electricity with a city's main power grid. The benefits of distribution grid management include increased reliability, reductions in peak loads, increased efficiency of the distribution system and improved capabilities for managing distributed sources of renewable energy (SmartGrid.gov, 2013 & McGeough et al., 2004).

3.6 Energy Generation:

It is stated by Schiller & Fassmann(2010) that, modern societies are already facing the global dilemma of increased demand for energy, while traditional energy generation resources are diminished. It became a worldwide phenomenon, therefore the global policy makers have begun crafting roadmaps to increase energy efficiency and sustainable green energy generation. There has been more talk of a transition to renewable energy on the grounds of climate change and an increasing range of public policies designed to move in this direction. In recent years, as a rational response to this problem, the old energy economy fuelled by oil, coal and natural gas; should being replaced by one source powered by wind, solar and geothermal energy(Baker & Steemers, 2005). Unlike the fossil fuel-based power, these sources of energy emit no or low GHG emissions, which is now identified as the largest single cause of global warming. On the other side, some cities are also trying to buffer themselves against energy price volatility and ensure energy security by generating power locally using local resources (UN-HABITAT and UNEP, 2009). But in a matter of fact turning around the world's fossil-fuel-based energy system and replacing it with an equally reliable alternative based on renewable energy flows is a difficult task that will require decades of expensive commitment. It must be mentioned that the timescale and lack of funds are the only possible critique of current renewable energy plans (Baker & Steemers, 2005).

3.6.1. Renewable Energy Generations:

According to the study done by Adefulu (1972) which concluded that, the renewable energy technologies can be summarized in three generation technologies. The first generation, which is already mature and economically competitive, includes biomass, hydroelectricity, geothermal power and heat. While the second one is being deployed at the present time, it includes solar heating, photovoltaic, wind power, solar thermal power stations and modern forms of bioenergy. The last generation technologies require continued efforts in order to make large contributions on a global scale, they mainly include advanced biomass gasification, hot-dry-rock geothermal power and ocean energy.

3.6.2. <u>Forms of Renewable Energy:</u>

Renewable energy is derived from natural processes that are replenished constantly with limited flow. This means that, they are virtually inexhaustible in duration, but limited in the amount of energy that is available per unit of time (Climate Change Challenge, 2007). The energy extracted from those sources is pollution-free, infinitely sustainable form of energy. They are often less damaging to the climate, as they create no greenhouse gases and no toxic wastes unlike the conventional energy sources (Adefulu, 1972). Here is a brief outline of the different types of renewable energy such as: energy generated from solar, wind, biomass, geothermal, hydropower, as well as biofuels, as shown in figure (3.90) (Renewable Solar Energy, 2011). There are various forms that reveal the classification of the renewable energy resources, as shown in figure (3.91). Among those forms are: the classification according to their target of their uses even for heat or generate electricity. The classification according to their connection with the grid, even they are off-grid or on-grid. The last one is the classification according to their location, even on-site or off-site.

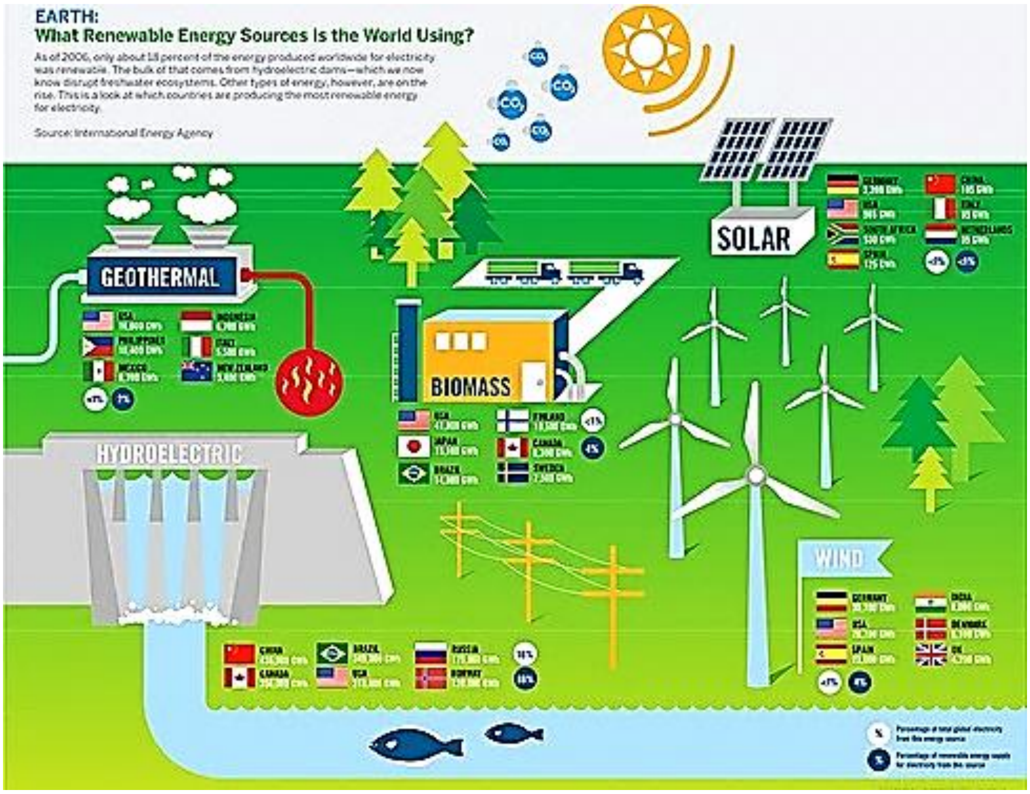


Figure (3.90): Renewable energy sources
Source: (Renewable Solar Energy, 2011)

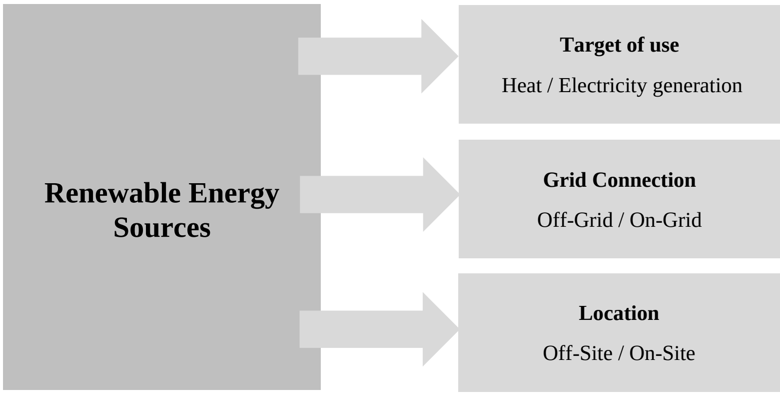


Figure (3.91): Calcification of renewable energy sources
Source: Adapted by the author

3.6.2.1. <u>Renewable Sources of Heat / Electricity:</u>

First, the renewable energy can be classified according to their target of their uses. As, there are renewables used for generating heat, those are named “Renewable sources of heat”. Others are used to generate electricity and they named “Electricity generation renewables”. It is worthwhile to consider that, many colder countries consume more energy for heating than electrical power, thus the renewable heat application is the most applicable in those countries. One of the good examples that use the energy of summer or winter sunshine to provide an economic supply of primary heat to a structure is the solar air heating or the water heating. Applications such those typically capture solar heat in panels, which can then be used for applications such as space heating and supplementation of residential water heaters (Baker & Steemers, 2005).

On the other side, generating electricity from renewable energy rather than fossil fuels offers significant public health benefits. Renewable electricity refers to electric power obtained from energy sources whose utilization does not result in the depletion of the earth’s resources. Renewable electricity also includes energy sources and technologies that have minimal environmental impacts, such as less intrusive hydro and certain biomass combustion. These sources of electricity normally will include solar energy, wind, biomass co-generation and gasification, as well as geothermal (Baker & Steemers, 2005).

3.6.2.2. <u>Grid Connection (Off-Grid / On-Grid):</u>

Before discussing the renewable energy supply options, it is essential to look at the issue of grid connection. Actually, there are two approaches which are off-grid and on-grid. The main difference between those two approaches is that, the off-grid does not have any connection to the utility grid, thus it does not purchase energy from the external sources (Marszal & Heiselberg, 2009). Also off-grid buildings cannot feed their excess energy production back onto the grid to offset other energy uses. This means that this energy production must be oversized in order to cover all the required energy (Pless & Torcellini, 2010).

On the other hand, the on-grid is also energy producing building, but there is a possibility for both purchasing energy from the grid and feeding it back to the grid (Marszal & Heiselberg, 2009). When the on-site generation exceeds the building's loads, excess energy production is exported to the utility to balance the energy loads in the building. This means that, a grid-connected uses traditional energy sources such as electricity and natural gas utilities when on-site generation from renewable energy does not meet the loads (Pless & Torcellini, 2010). Conceptually, the ideal situation is the zero energy building, which produces more energy than it uses annually and exports excess energy generation to the utility electricity grid, or any other central energy distribution system to offset the energy used (Marszal & Heiselberg, 2009). However, in high market penetration scenarios, the grid may not always need the excess energy (Pless & Torcellini, 2010).

3.6.2.3. <u>Renewable Sources: Off-Site / On-Site:</u>

In another definition, the concept of a net zero energy building encompasses two options of supplying renewable energy, which can offset the energy use of a building, in particular on-site or off-site renewable energy supply, as shown in figure (3.92). Currently, the on-site options are much more popular than the off-site, however the limited area of the roof and façade should be taken into consideration (Joanna et al., 2012). In terms of both, the site conditions should take into consideration such as the available sun or wind, besides the ease of connecting the project to the power grid (Smith, 2013).

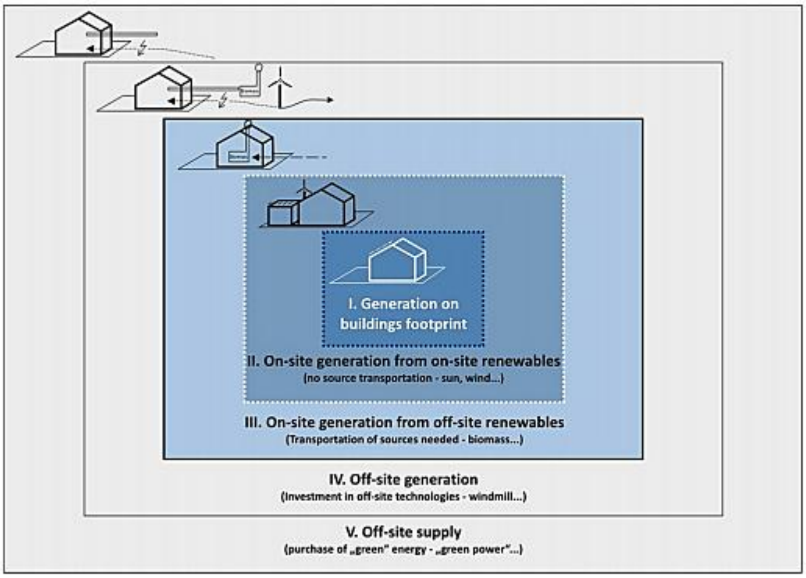


Figure (3.92): Overview of possible off-site and on-site renewable supply options
Source: (Marszala A. et al, 2010)

I. <u>Off-site:</u>

It is stated by Baker & Steemers (2005) that, off-site projects have the opportunity to be sited in much better locations than can on-site ones. In addition, another study by Smith (2013) also stated that, off-site systems are often less expensive to install and maintain than many on-site projects, which lead to provide great saving to the user. Off-site systems also help to overcome the size limitations that confront many on-site systems (Baker & Steemers, 2005). Beyond the ability to create larger, more meaningful projects, off-site systems present the flexibility of a scalable system. This means an institution can size a project based on desired energy output rather than on available space on the site (Smith, 2013). To calculate the amount of the neighborhood's energy demand that must be met with off-site supplies, the estimated on-site production should be subtracted first from the neighborhood's total electric needs, in order to find the amount of electricity that must be imported into the neighborhood's electric grid (Allen & McKeever, 1996). Actually, there are numerous forms that reveal the off-site renewable energy sources. Among those forms are:

- **Biomass / Biogas:** Alternative energy solutions powered by biogas or biomass can produce both heat and power. The biogas power plant gathers methane from biological materials such as landfills and animal manure from farms. While the biomass power plant generates energy from wood and wood by-products such as residue from forestry and sawmills time (Climate Change Challenge, 2007). The simplest method of converting biogas or biomass to energy involves burning the biogas or the wood products in an off-site boiler to produce steam, which is then used to turn a turbine. This turbine is connected to a generator which produce heat and electricity to be used by the building (FortisBC, 2013).

- **Solar Farms:** Solar farms are large collections of interconnected solar panels that work together to capture sunlight and turn it into electricity on a grand scale. It is worth mentioning that, those solar panels produce electricity quietly unlike the energy produced from the use of fossil fuels and some other types of renewable energy which can be noisy (Climate Change Challenge, 2007). The two main types of solar farm are photovoltaic and parabolic. Photovoltaic panels are the same panels that install on the home's roof to capture sunlight, but only on a much larger scale. In this type, the sunlight strikes the cell and sends electrons racing towards electrical conductors to produce a direct current. While parabolic panels are large, curved mirrors that capture sunlight and reflect it onto an oil-filled pipe in the mirror's center. In this type, the oil heats up and then flows to a steam generator where it boils the water and generates electricity. Some of those farms are government owned, while others are privately owned (Charles, 2008). It is also worth mentioning that, solar energy is a clean renewable energy source and large solar farms produce enough energy to provide clean energy to the buildings that do not have their own solar energy systems. Hence, solar farms can reduce the need for non-renewable energy sources to power the grid (Climate Change Challenge, 2007). On the other side, the cost is a major limiting factor in the development of solar farms, but prices are expected to drop as technology improves (Charles, 2008).

- **Wind Farms:** Wind generation of electricity has a promising future at both small and large scales. Large wind farms consist of hundreds of individual wind turbines, which are connected to the electric power transmission network. This means that, the decision to utilize wind power is largely out of the architect's control. It is preferred to build wind farms in places that have strong and steady winds with an average wind speed around 25 km/h. (Baker & Steemers, 2005). It is also worth mentioning that, the best places for wind farms are in coastal areas, at the tops of rounded hills, open plains, as well as gaps in the mountains. In general, any place where the wind is strong and reliable (Energy Resources, 2013). Studies and researches showed that, offshore wind is steadier and stronger than on land, also offshore farms have less visual impacts, but construction and maintenance costs are considerably higher. Also, wind turbines can be used as standalone applications, or they can be connected to a utility power grid or even combined with a photovoltaic system. It is agreed that, wind power is distributed clean renewable energy source, which produces no greenhouse gas emissions during operation. The effects on the environment are generally less problematic than those from other traditional power sources. The only disadvantage of wind turbines that, the sounds they produce are typically noisy, but as turbine technology has improved over the years, which consequently decrease the amount of sound (Climate Change Challenge, 2007 & Energy Resources, 2013).

II. <u>On-site Energy Generation:</u>

On the other side, the on-site renewable energy systems are also a potential source of revenue for local governments, building owners and occupants. They can be used in supplying electricity or heating and cooling energy to buildings, in addition to charging stations for electric vehicles (Smith, 2013 & National Institute of Standards and Technology, 2012). It is quite important to mention that, there are numerous names can represent the same meaning of generating electricity from many small energy sources, such as distributed generation, dispersed generation, embedded generation, as well as decentralized energy or distributed energy generation, all of them represent achieve the same target (McGeough et al., 2004 & Smart Grid. gov, 2013). They are smaller units offered greater economies from mass-production than big ones could gain through unit size (Rocky Mountain Institute, 2002). On the other side, Smith (2013) stated that, the generation cost of those distributed generation sources is more expensive than conventional sources, although they help to reduce the amount of energy lost in transmitting electricity. This may be returned to the reason that, the electricity is generated very near or even in the same building where it is used and this consequently reduces the size and number of power lines that must be constructed. There are numerous forms that reveal the on-site renewable energy sources, those technologies are not necessarily appropriate for use on individual buildings or building sites. Among those forms are:

- **Photovoltaic Panels:** Photovoltaic Panels are considered to be one of the sources that used to generate on-site energy. The panels are relatively easy to integrate into the design of the house early in the conceptual design stage (Climate Change Challenge, 2007). There are several aspects of the design of photovoltaic systems that can significantly affect the performance of the system such as the location and angle of the collector, internal losses, shading, as well as the temperature of the panels. It is worthwhile to consider that, the collector plate should be installed on the south side of the building. Variations within 15 degrees of true south will create relatively little changes in the performance of the panels. Most systems will face some internal losses in the system from dirt, dust, the resistance in the wiring, elevated temperature of the panels and losses through the inverter, all of them decrease the performance of the system. Therefore, it is very important that the panels are placed in a location do not cast a shadow over the panel. On the other side, it is important to try to keep the panels as cool as possible. As the temperature of the panel increases, the output of the panels is reduced. So it is preferred to install the panels slightly off the surface of the roof, to allow for some ventilation behind the panels (Charles, 2006).

PV systems are typically roof-mounted or ground-mounted, this is probably the most effective way to actively exploit solar power, as shown in figure (3.93). The panels may be fixed or they may track the sun, which increases both generation and installed costs (Charles, 2006). Although they can also be integrated into vertical walls or integrated into some conventional building envelope materials. For example, photovoltaic panels can be integrated into windows, walls and spandrel glasses, as well as become part of the building's skin, as shown in figure (3.94) (Continuing Education, 2012). In general, photovoltaic systems are either connected to a battery storage system located on-site, or connected into the power grid of the community (Building Energy Smart, 1997). From a few years ago, the PV system is cost effective from a payback point of view, as the amount of energy generated was taken many years to pay off the initial cost of the panels. But nowadays, as the use and demand for PV technology increase, as well as further advances in the technology increase the performance of the panels, the costs will continue to drop which make the technology more viable financially (Charles, 2006).

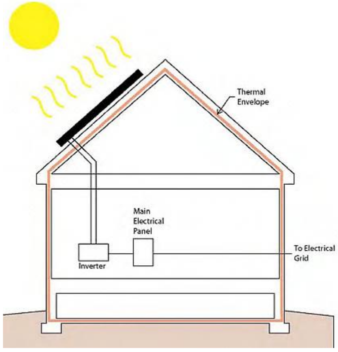


Figure (3.93): PV on building's roof
Source: (Charles, 2006)

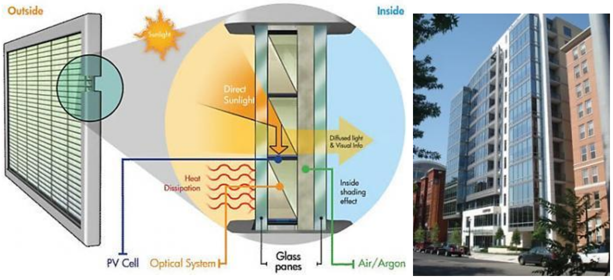


Figure (3.94): PV cells integrated into the window
Source: (Continuing Education, 2012)

Also, at the present days cities have taken the initiative and begun replacing incandescent signals with more efficient light emitting signals, which use 90% less power and last ten times longer than the traditional incandescent bulbs, as shown in figure (3.95) (Building Energy Smart, 1997). As, converting street lights and traffic signals with low energy systems like led or solar powered lighting systems can provide significant energy efficiency. On the other hand, the panels also can be integrated into the design of the parking lots such as in BedZED, as shown in figure (3.96).

Figure (3.95) Example of the exterior light
Source: (Zedfactory, 2014)

Figure (3.96): Pv on parking lots at BedZED
Source: (Lazarus, 2002)

- **Thin Solar Cells:** These cells are lightweight, cost effective and more flexible than previous generations of photovoltaics. They are new effective thin-layer technology of plastic photovoltaics that can be used in many applications where traditional photovoltaics cannot compete (Pagliaro et al., 2008). The thin- layer photovoltaic modules functionality can be integrated at low cost into the existing structures of the buildings. They are about printing rolls and can be installed anywhere on windows, roofs, as well as external walls. They are installed directly without frames, without covers and without assembly frameworks, as shown in figure (3.97) (Energies-Renouvelables, 2012). It is also worth mentioning that, the homogeneous black color and pinstriped appearance of the modules, give additional advantages in comparison to other PV material products, as shown in figure (3.2) (Solar Daily, 2010).


Figure (3.97): New flexible solar modules
Source: (Energies-Renouvelables, 2012)


Figure (3.98): Example of the solar modules
Source: (Solar Daily, 2010)

- **Solar Water Heaters:** Solar water heaters can be one of the most cost effective on-site renewable options. They use the sunlight to heat water for service hot water demands. They are being tested as a source of thermal energy for single and double effect absorption chiller systems, which could meet a significant portion of the neighborhood's hot water demand. Evacuated tube collectors will be roof-mounted to provide domestic hot water and a base load that can be used for de-humidification. It is also worth mentioning that solar hot water may be impractical in buildings with several small distributed hot water systems, like apartments. This system typically includes roof-mounted panels or evacuated tubes, an insulated storage tank, pipes, pumps and controls, as shown in figure (3.99) (Baker and Steemers, 2005).

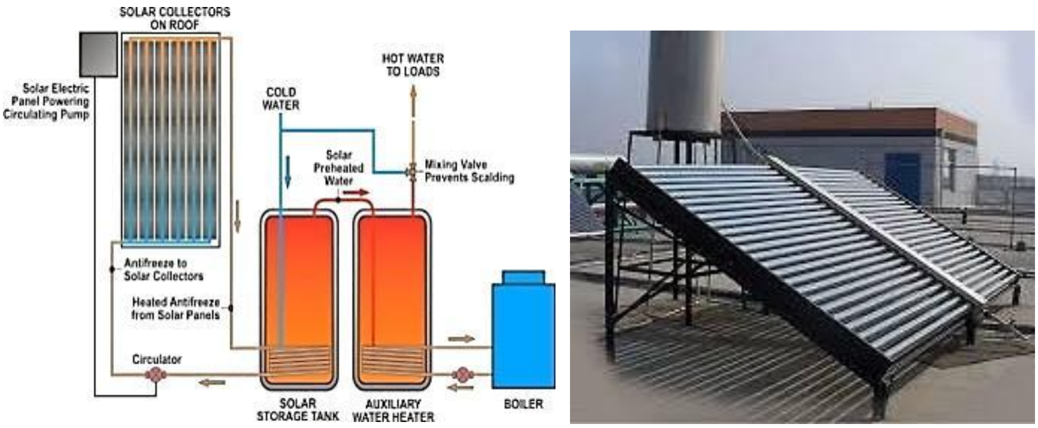


Figure (3.99): Examples of solar heating system
Source :(The Furman Farm- Sustainable Production and Living, 2010)

- **Geothermal Heat Pump Systems:** Geothermal energy is a clean heat and power resource that emits little or no greenhouse gases. According to the study by Allen & McKeever (1996) which stated that, geothermal heat pump systems take advantage of the fact that the ground is cooler than the air above it in the summer and warmer than the air above it in the winter. It mainly depends on the advantage of the consistent temperature found below the earth's surface and uses it to heat and cool buildings. In the summer excess heat is removed from indoor air and pumped into the ground and in the winter thermal energy is gained from the ground and transferred into the building. The system is mainly made up of a series of pipes installed underground and connected to pipes in a building, as shown in figure (3.100). A pump circulates liquid through the circuit. In the winter the fluid in the pipe absorbs the heat of the earth and uses it to heat the building, while in the summer the fluid absorbs heat from the building and disposes it in the earth. This system is more efficient than ordinary heating and air conditioning systems, it can also be used to aid in hot water heating. On the other side the maintenance and service costs are significantly lower than conventional HVAC systems (Allen & McKeever, 1996 & Geothermal Resources Council, 2013).

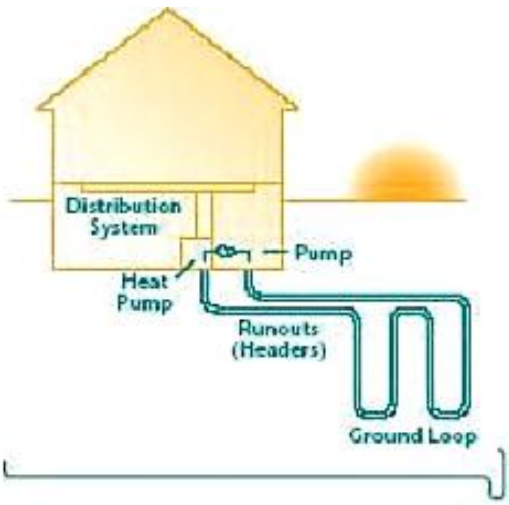


Figure (3.100): A diagram of a geothermal heat pump system
Source: (Allen & McKeever, 1996)

- **Mini Wind Turbines:** It is recommended to use mini wind turbines, which are designed especially for urban areas. They should be insulated on the roof, in areas without buildings or other elements that can block the wind. These are very low-power turbines have a maximum electricity production capacity of 100 KW, as shown in figure (3.101, 3.102). It can be connected to the power network or it can be used as a power to the applicants inside the home. However, the actual performance of building-integrated wind is often lower than expected. There are many legitimate concerns regarding noise and vibrations caused by building-integrated wind systems. The cost-effectiveness of building-integrated wind is not nearly as good as commercial scale wind and is often worse than on-site PV systems (PRWEB, 2010).

Figure (3.101): Building-integrated wind
Source: (PRWEB, 2010)

Figure (3.102): Example of the mini wind turbines used at buildings
Source: (Chino, 2008)

To sum up, it can be said that the electric generation technologies listed above are known as distributed energy sources rather than centralized power plants. These plants are smaller and cleaner than conventional generation systems, which consequently have great influence over the climate change and energy security (Adefulu, 1972). It is also worth mentioning that, those resources are available year after year in rather steady amounts in all parts of the world, they not finite like coal, oil, natural gas and nuclear. Add to that, there are not required new breakthroughs for their widespread use, although improvements in technology and new developments in some areas could help in lowering their costs, also make some sources more practical. It also has a great prevailing that, it permits the individuals to control their own power production. While, on the other side, there are some down sides of renewable energy technologies, as they often require some means of storage so surpluses which can be used later, but actually storing renewable energy can be difficult and costly. Besides, converting to renewable energy technologies may need to be done on a house-by-house basis, which will require the efforts of millions of homeowners. The last important thing that, the renewable energy research and development are poorly funded in most countries, compared to conventional fossil fuels (Chiras, 2006).

3.7. Energy Codes and Standards:

It is stated by Bartlett et al. (2003) that, energy standards and codes are the legal requirements that regulate buildings' energy performance and address energy consumption in the building envelope and building equipment, such as heating, cooling and lighting. Energy codes and standards play a vital role by setting minimum requirements for energy efficient design and construction. In general, they outline uniform requirements for new buildings as well as renovations (Rocky Mountain Institute, 2012). Therefore, the following sections discuss briefly some of the energy codes and standards that can be applied on the residential buildings. Overall, building energy codes are designed to improve energy services, including comfort for occupants at low energy consumption. The ultimate objective is to transform the buildings from energy consumers to energy producers. Future updates to building energy codes will target nearly zero energy consumption and will include all end users. This target can be achieved by moving to a comprehensive holistic approach in which the combination of these three pillars of the energy efficiency can be achieved. It must be mentioned that, the combination between energy consumption, energy distribution and supply from renewable energy sources, represent the modern approach for designing effective building energy codes (Tebbets, n.d). Those codes help to reach energy efficient buildings, which offer energy, economic and environmental benefits. They also create economic opportunities for business and industry by promoting new energy efficient technologies (Bartlett et al., 2003).

On the other side, it is worthwhile to consider the difference between the energy code and the energy standards. The main difference between energy codes and energy standards specify how buildings must be constructed or perform (Bartlett et al., 2003). In general, energy standards describe how buildings should be constructed to save energy cost effectively (Tebbets, n.d). They are published by national organizations such as the American Society of Heating, Refrigerating and Air Conditioning Engineers like (ASHRAE). They are not mandatory, but serve as national recommendations, with some variation for regional climate. States and local governments frequently use energy standards as the technical basis for developing their energy codes. While on the other side, some energy codes are written in mandatory, enforceable language, making it easier for jurisdictions to incorporate the provisions of the energy standards, codes into their laws or regulations (Bartlett et al., 2003). One of the best examples that show how in which the state and local jurisdictions can easily adopt a model as their energy code is the International Energy Conservation Code (IECC), which is published by the International Code Council (ICC) and was adopted to be as a model code by many states and municipal governments in the United States (Responsible Energy Codes Alliance (RECA), 2011).

3.7.1. Examples of Energy Codes:

To sum up, it can be said that, the advanced energy codes set minimum energy performance that takes into account the long-term economic and energy security considerations. This approach supports increasing the stringency of energy requirements within the codes to exploit improvements in technologies and changes in local environmental and socioeconomic contexts (Bartlett et al., 2003). This part will provide an introduction to some commonly used codes. Among those codes are:

I. International Energy Conservation Code (IECC):

The International Energy Conservation Code (IECC) is a building code created by the International Code Council (ICC) in 2000 (International Code Council, Inc., 2011). It is a model code adopted by many states and municipal governments in the United States for the establishment of minimum design and construction requirements for energy efficiency. It is referred to as a model code because it was developed through a public hearing process by national experts under the direction of the International Code Council (ICC). It is also worth mentioning that, states and local jurisdictions, most often look to national model energy codes as the starting point for their own codes, as the adaptation of the model energy codes makes it easier for them to keep current with the most recent building practices and technology (Bartlett et al., 2003).

The IECC sets minimum energy efficiency provisions for both residential and commercial buildings (Bartlett et al., 2003). Users of the code can choose between two methods for showing compliance, the prescriptive and performance paths. The prescriptive path of the code sets specific minimum performance levels for each of the components of the building envelope, such as ceiling and wall insulation, window U-factor, solar heat gain coefficient (SHGC) and air infiltration. For each component, these prescriptive requirements must be met or exceeded, without the ability to trade-off between components. Although, it allows less flexibility, this path can be more straightforward to comply with. While, in the performance path, users can have performance of components that are lower in one area, as long as they make up for it with higher performance in another area. Energy calculations are used to determine if the trade-offs are equivalent (International Code Council, Inc., 2011). In some cases, additional requirements necessitate the use of the performance path for instance, if a commercial building wants to exceed 40% windows to wall area, it must use the performance path (Responsible Energy Codes Alliance (RECA), 2011).

It is also worth mentioning that, the IECC is updated on a three year cycle, with the most recent being the 2012 IECC. All the versions of the IECC such as: 2006 IECC, 2009 IECC, 2012 IECC have requirements that cover new construction, additions, remodeling, window replacement and repairs of specified buildings. The residential part of the code applies to the buildings that are detached one and two family dwellings. In addition to the buildings that contain three or more dwelling units and are three stories or less in height above grade. The code provisions are intended to ensure the design of energy efficient building envelope requirements by focusing on insulation requirements for ceilings, walls and floors and on the thermal conductance of windows and doors. They also address the energy efficiency of elements that do not affect the building envelope, such as mechanical, water heating, electrical and lighting equipment (International Code Council, Inc., 2011 & Responsible Energy Codes Alliance (RECA), 2011). Another concern is that, the code requirements vary by region, in which the regions are determined based on the climate and they are called climate zones. Each county is sorted into one of eight climate zones across the United States and sub-categorized according to the climate type, if it is moist, dry and marine. Actually, there are numerous requirements are varied by the climate zones such as insulation levels and fenestration U-factors (Bartlett et al., 2003).

II. German Energy Saving Ordinance (EnEV):

The Energy Saving Ordinance "Energieeinsparverordnung (EnEV)" is an important part of the energy and climate policy of the German Federal Government. The EnEV mainly aims to increase the energy efficiency of buildings and the use of renewable energies (Federal Ministry of Economics and Technology (BMWI), 2008). It is worthwhile to mention that, Germany first introduced regulations to improve the insulation of buildings in 1979 when the government implemented its first heat insulation ordinance (Wärmeschutzverordnung, WSchV). Just one year later the Heating Systems Ordinance (HeizAnlV 1978) came into effect and established a statutory basis for enhanced energy efficiency in systems engineering (IDEAL-EPBD, 2013). After that, a greater emphasis was gradually placed on climate protection due to climate change. In Germany, this directive was implemented into national law with the introduction of the Energy Saving Regulation (EnEV) in 2002. For the first time, this legislation provided a way of creating an eco-balance of a building by counting not only the useful energy provided to the building, but also the primary energy needed in the process, which includes losses in generation, distribution, storage. In addition, EnEV includes requirements for the quality of renovation steps, energy audits and replacements for old heating systems (Horst & Kunkel, 2010).

Since the implementation of the EnEV in 2002, the primary energy demand of new buildings has been limited. Also, existing buildings which are being renovated or extended have to comply with specific minimum standards. Then a series of reforms for the implementation of the European Guideline on the Final Energy Efficiency of Buildings (2002/91/EC) were introduced with the EnEV 2007 (Federal Ministry of Economics and Technology (BMWI), 2008). In 2009, the EnEV 2009 was established, upon the implementation of it, the energetic minimum standards were increased by 30% (Horst & Kunkel, 2010). In order to implement the recast European Directive on energy performance of buildings, the EnEV was amended again in 2013. EnEV 2013 was published on the 21st November 2013 in the official Bulletin ("Bundesgesetzblatt") and will get into force after a transition period on 1st May 2014. It is worth mentioning that, the level of requirements was adjusted once more in this course and it will replace the EnEV 2009 (IDEAL-EPBD, 2013).

In general, the EnEV defines demands on energy efficiency in new buildings and renovated buildings (Horst & Kunkel, 2010). Energy efficiency is measured using the annual primary energy requirement of a building as well as the thermal insulation of the building envelope. Also, the energy efficiency of the building appliances used such as heating, domestic hot water, ventilation, cooling and lighting are taken into account. It is first and foremost aimed to save heating costs and to reduce environmentally harmful greenhouse gases such as CO_2 (IDEAL-EPBD, 2013).

From the implementation of the EnEV 2007, there is energy labelling of existing residential buildings, which became compulsory by 2008 (Federal Ministry of Economics and Technology (BMWI), 2008). The study by Horst & Kunkel (2010) showed that, buildings or apartments that are rented, leased or sold must have an energy label. The study also explained that, there are two types of energy labels for residential buildings currently in use, which are the label based on energy demand and the label based on energy consumption, as shown in figure (3.103). It is also worth mentioning that, the label based on energy demand is obligatory for any new and renovated or extended residential buildings and includes the calculated primary and final energy demand.

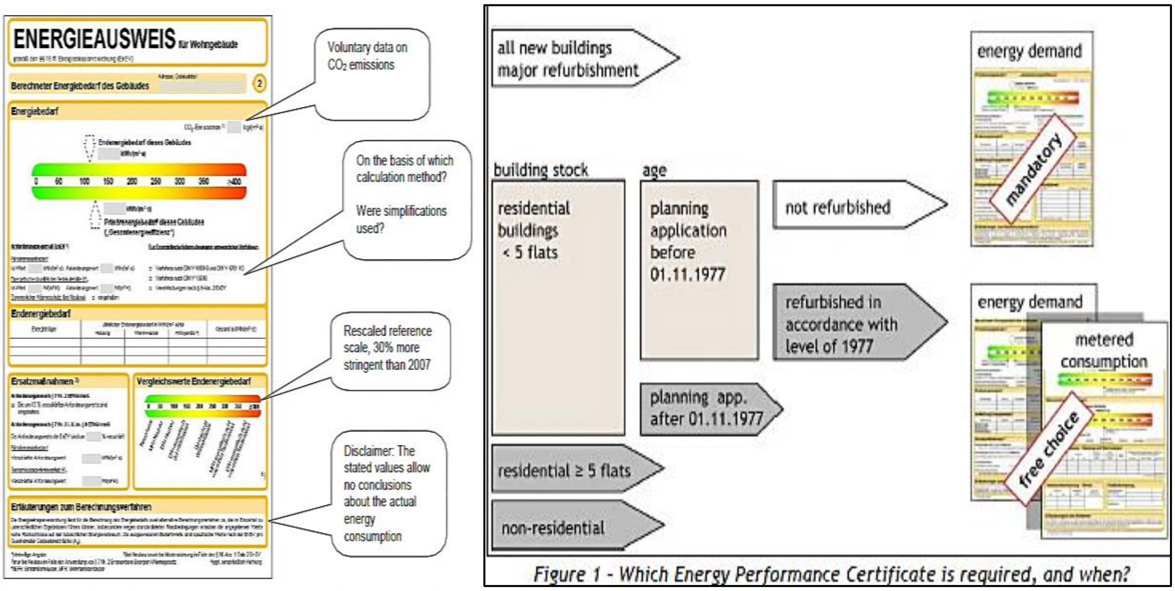


Figure (3.103): Shows the energy labels for residential buildings
Source:(Horst & Kunkel, 2010)

3.7.2. <u>Examples of Energy Standards:</u>

On the other hand, there are numerous organizations which have developed high energy efficiency performance standards. These standards are voluntary and are meant to lead the practice by setting a benchmark higher than code. Those voluntary standards may be used by builders or designers to provide an accepted benchmark or as the basis for building code requirements by some jurisdictions wishing to go further than the standard requirements (Bartlett et al., 2003). Also, they can help motivate consumers to recognize the value of energy efficiency of their homes (Tebbet, n.d). This part will provide an introduction to some commonly used standards and an overview of the most widely recognized energy efficient building product standards currently in use with an emphasis on how they vary. Among those standards are:

I. ASHRAE Standard 90.1:

The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), founded in 1894, it is a building technology society with more than 50,000 members worldwide. The society and its members focus on building systems, energy efficiency, indoor air quality, refrigeration and sustainability. It is also worth mentioning that, the original Standard 90 published in 1975 (ASHRAE/IESNA Standard 90.1, 2007). As the technology and energy prices began changing more rapidly, the standard updated rabidly. At the beginning, it was printed to be updated several times each year, while with the 2001 edition, a new edition would be published every three years (Bartlett et al., 2003).

It is obvious that, ASHRAE shapes tomorrow’s built environment, as the purpose of this standard is to provide minimum requirements for the energy efficient design of buildings except low-rise residential buildings. In general, it is a reference for engineers and other professionals involved in the design of buildings and building systems (Bartlett et al., 2003). As it offers, in detail, the minimum energy efficiency requirements for the design and construction of new buildings and their systems, in addition to the new portions of the buildings and their systems, as well as the new systems and the equipment in existing buildings. Finally, it offers criteria for determining compliance with these requirements. The provisions of this standard apply to the envelope of buildings, heating, ventilating and air conditioning, service water heating, electric power distribution and metering provisions, electric motors and belt drives and lighting (ASHRAE/IESNA Standard 90.1, 2007).

II. ENERGY STAR®:

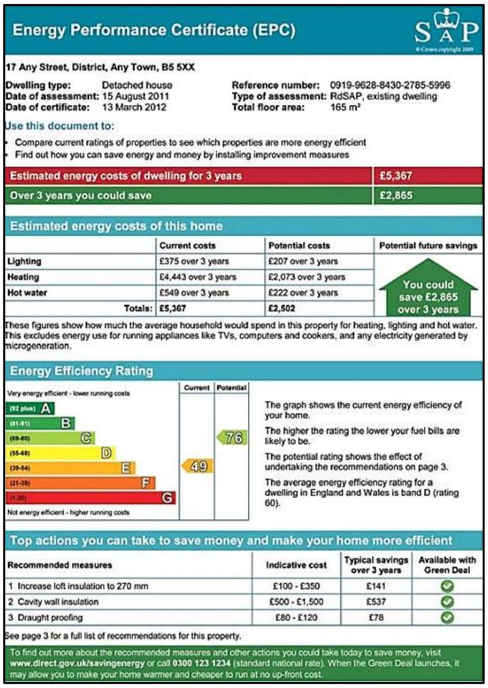
An additional example of a positive energy stander is the ENERGY STAR scheme. ENERGY STAR® is a well-known federal program initiated in 1992 by the U.S. Environmental Protection Agency (EPA). Building professionals can use the prescriptive requirements of the Energy Star® for homes program, in order to achieve energy performance in homes (Tebbets, n.d). It is worthwhile to consider that, ENERGY STAR homes are typically 30 percent more energy efficient than building complies the base code and it is also awarded to any new buildings with energy performance at least 15% better than the 2006 IEEC code (ENERGY STAR, 2013)

It is acknowledged that, the U.S. Environmental Protection Agency (EPA) joined with the United States Department of Energy (DOE) to develop this program as a way to encourage and recognize products of many types that excel in their ability to go beyond simply meeting the minimum federal standards for energy efficiency. It is also agreed that, the familiar blue and white ENERGY STAR® label has become a recognized symbol for energy efficiency, which is earned by demonstrating performance through various testing (ENERGY STAR, 2013). In general, it is intended to help consumers save money and protect the environment through the proliferation of energy efficient buildings, products and practices over less efficient alternatives (Tebbets, n.d). It is also worth mentioning that, the program is completely voluntary, but has been embraced by many companies as means to distinguish their products and demonstrate their commitment to energy efficiency, which has become a requirement of many consumers. Also, it has been connected with tax exemptions and has played an important role in transforming energy markets towards higher energy efficiency in the United States (ENERGY STAR, 2013)

III. <u>Energy performance certificates (EPC):</u>

In 2006, the Government in England and Wales introduced new building regulations, which raised the energy efficiency standards. In order to meet these building regulations, builders need to make sure that any new homes they build must have an EPC certificate. It is agreed that, EPCs certificate is required whenever a building is constructed and also for existing buildings, before it is marketed for sale or rent (Bartlett et al., 2003). It is apparent that, the idea of the EPC is similar to the well-established energy labels for the sale of white goods such as fridges and washing machines. EPC is produced using standard methods with standard assumptions about energy usage so that the energy efficiency of one building can easily be compared with another building of the same type. It records the energy efficiency of a property, providing a rating of the energy efficiency and carbon emissions of a building on a scale from A to G, where A is very efficient and G is very inefficient (Department of Finance and Personnel, 2014). Besides, they let the person who will use the building know how costly it will be to heat and light and what its carbon dioxide emissions are likely to be. As it provides a recommendation report listing cost effective and other measures to improve the energy rating of the building, if all the recommendations were implemented the house will gain a better rating (Bartlett et al., 2003).

For dwellings, two ratings are shown, the current rating and the potential rating. The actual energy efficiency rating is the measure of the dwelling's overall efficiency. The higher the rating, the more energy efficient the dwelling is, the lower the associated carbon emissions are and the lower fuel bills. On the other side, for non-dwellings, the actual energy efficiency rating is the measure of the building's overall efficiency. The energy efficiency rating is based on the performance of the building itself and its services such as heating and lighting, rather than the domestic appliances within it. The higher the rating, the more energy efficient the building is (Department of Finance and Personnel, 2014). Ratings will vary according to the age, location, size and condition of the building. The potential rating on the certificate will take these factors into account and the suggested measures will be tailored so that they are realistic for the particular building (Bartlett et al., 2003). Figure (3.104) shows an example of EPC certificate.



Energy Performance Certificate (EPC)

17 Any Street, District, Any Town, B5 5XX

Dwelling type: Detached house
Date of assessment: 15 August 2011
Date of certificate: 13 March 2012
Reference number: 0919-9628-8430-2785-5996
Type of assessment: RdSAP, existing dwelling
Total floor area: 165 m²

Use this document to:

- Compare current ratings of properties to see which properties are more energy efficient
- Find out how you can save energy and money by installing improvement measures

Estimated energy costs of dwelling for 3 years	£5,367
Over 3 years you could save	£2,865

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£375 over 3 years	£207 over 3 years	You could save £2,865 over 3 years
Heating	£4,443 over 3 years	£2,073 over 3 years	
Hot water	£549 over 3 years	£222 over 3 years	
Totals:	£5,367	£2,502	

These figures show how much the average household would spend in this property for heating, lighting and hot water. This excludes energy use for running appliances like TVs, computers and cookers, and any electricity generated by microgeneration.

Energy Efficiency Rating

Very energy efficient - lower running costs
(92 plus) A
(81-91) B
(69-80) C
(55-68) D
(39-54) E
(21-38) F
(1-20) G
Not energy efficient - higher running costs

Current: 49
Potential: 76

The graph shows the current energy efficiency of your home.

The higher the rating the lower your fuel bills are likely to be.

The potential rating shows the effect of undertaking the recommendations on page 3.

The average energy efficiency rating for a dwelling in England and Wales is band D (rating 60).

Top actions you can take to save money and make your home more efficient

Recommended measures	Indicative cost	Typical savings over 3 years	Available with Green Deal
1 Increase loft insulation to 270 mm	£100 - £350	£141	✓
2 Cavity wall insulation	£500 - £1,500	£537	✓
3 Draught proofing	£80 - £120	£78	✓

See page 3 for a full list of recommendations for this property.

To find out more about the recommended measures and other actions you could take today to save money, visit **www.direct.gov.uk/savingenergy** or call **0300 123 1234** (standard national rate). When the Green Deal launches, it may allow you to make your home warmer and cheaper to run at no up-front cost.

Figure (3.104): Shows the EPC certificate
Source :(Department of Finance and Personnel, 2014)

IV. Home Energy Rating System (HERS):

Additionally, there is the HERS Index by which a home's energy efficiency can be measured (Tebbets, n.d). It is an industry standard developed and introduced by the Residential Energy Services Network (RESNET) in 2006 (RESNET HERS Index, 2013). It is worth mentioning that, the government agencies such as the Department of Energy (DOE), Department of Housing and Urban Development (HUD) as well as the

Environmental Protection Agency (EPA) recognizes the HERS Index as an official verification of energy performance. In addition to that, the Boulder County and the City of Boulder also require a projected HERS rating in order to receive the building permit for any owner (Residential Energy Services Network (RESNET), 2014). At the same time, it is important to mention that, the HERS Index was mainly based on the 2006 International Energy Conservation Code, as the RESNET initiative sets it out to prove that housing can be designed and constructed to be 60% more efficient than the 2006 IECC, for about the same cost as just meeting the code (RESNET HERS Index, 2013).

It is apparent that, this scoring system is used to help in comparing between homes objectively, as it compares the energy efficiency of a home to a computer simulated reference house. The rating involves analysis of the home's construction plans and at least one on-site inspection (Sustainably Built, 2014). The study also by Bartlett et al., (2003) claimed that, this information is used to estimate the home's annual energy costs and give the home rating a score of 100. The lower a home's HERS Index, the more energy efficient it is. In comparison to the HERS Reference Home, this means that a net zero energy home scores a HERS Index of 0, as shown in figure (3.105) (Sustainably Built, 2014). It is also agreed that, each 1-point decrease in the HERS Index corresponds to a 1% reduction in energy consumption compared to the HERS Reference Home. This means that, a home with a HERS Index of 85 is 15% more energy efficient than the HERS Reference Home and a home with a HERS Index of 80 is 20% more energy efficient(RESNET HERS Index, 2013).

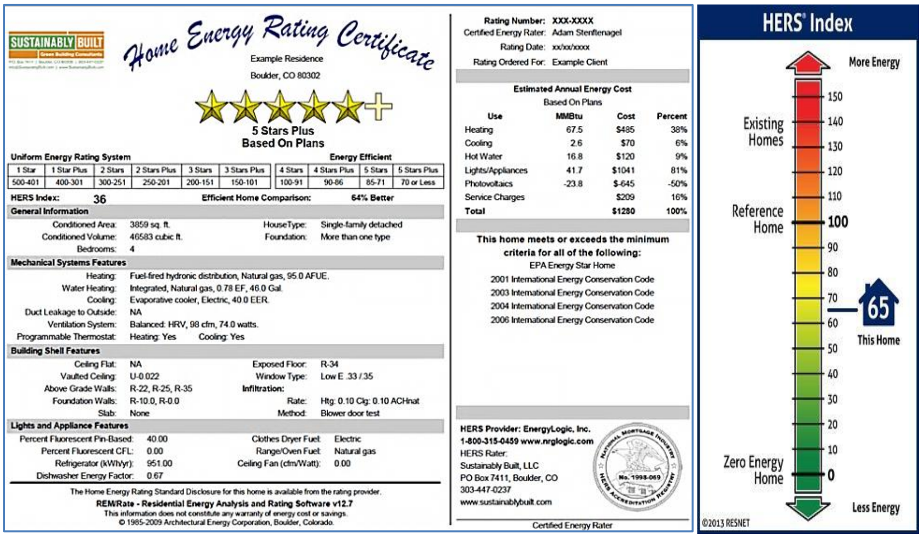


Figure (3.105): Shows the HERS certificate and HERS Index Score
Source :(Sustainably Built, 2014)

In addition to the HERS Index Score, the home energy rating also provides the homeowner with a detailed report regarding energy problems in the house . Actually, it gives the owner the ability to equate different changes over the years and see what areas can be improved (Tebbets, n.d). The rating HERS consists of diagnostic testing using specialized equipment, such as a blower door test, duct leakage tester, combustion analyzer and infrared cameras to show what cannot be seen with the visible eye (Residential Energy Services Network (RESNET), 2014). It is worthwhile to consider that, the HERS rating records the insulation values of foundations, walls, attic, windows, orientation of the house as well as the efficiency of the HVAC units, ducting, water heater and other appliances, in order to give measure to all the energy components of the house. Moreover, HERS rating also uses the Blower Door to depressurize the house so it can be determined how tight the building envelope is to air infiltration. Also, the Duct Blaster is also used to determine how tight the HVAC ducting (RESNET HERS Index, 2013).

The results of these tests will be entered into the original energy model and a confirmed rating will be generated in computing to the against a reference home. This reference home is a design modeled home of the same size and shape as the actual home (RESNET HERS Index, 2013). The U.S. Department of Energy has determined that, a typical resale home scores 130 on the HERS Index while a standard new home is rated at 100. At home with a HERS Index Score of 70 is 30% more energy efficient than a standard new home. While a home with a HERS Index Score of 130 is 30% less energy efficient than a standard new home (Sustainably Built, 2014).

3.7.3. <u>Difference between Rating Systems and Energy Code:</u>

It is quite important to mention the difference between the rating systems and the codes. It is obvious that, the rating systems may not guarantee energy efficiency (Tebbets, n.d). As mainly the most of the rating systems recognize to the buildings that meet certain standards in categories such as site, water, energy, materials and indoor environmental quality (Reed et al., 2009). Each category has prerequisites that must be met, users can choose the remainder of credits required for certification from the various categories, depending on their own priorities. Energy efficiency may or may not be one of those priorities (Yigitcanlar & Dur, 2010). In general, the rating systems are voluntary and do not require the use of renewable energy sources, but provide points towards the required energy credits (Tebbets, n.d). Thus, trying to use a rating system, such as LEED system, as a building energy code leads to problems when it measures the energy efficiency of the building (Tebbets, n.d). As, the buildings designed using a rating system such as LEED 2009 for New Construction for example, are required to achieve only 10 percent energy reduction (Tebbets, n.d). This percentage is considered to be a very low percentage if it is compared to the other energy codes or standers mentioned previously. From another perspective, it is also difficult to enforce the rating systems as energy code, this may be extended to reason that the building codes are written in normative language, whereas rating systems are not (Bartlett et al., 2003).

To sum up, it can be said that the codes and the standards are the critical parts of the energy crisis. As mentioned before, the housing stock will change dramatically with new construction, which leads to over consumption of energy sources and this consequently have negative impacts on the environment. Therefore, there is a big need for scalable, affordable solutions, in order to get ahead of the new codes and avert the detrimental effects of inefficient buildings. This is mainly the communities' opportunity to achieve their efficiency goals and begin to imagine communities of energy independence (Bartlett et al., 2003 & Residential Energy Services Network (RESNET), 2014).

From the other side, the energy codes are advancing more rapidly, thus there is a big need to increase the awareness of how to choose the most appropriate one (Residential Energy Services Network (RESNET), 2014). Therefore, comparing different building codes and standards gives an imperfect understanding about which code can be used to achieve the required energy efficiency before deigning the house (Tebbets, n.d). As an example, there are over than 3,000 code jurisdictions in the U.S. only. The figure below (3.106) shows a comparison of residential energy codes and standards on relative to HERS Index. The design and construction community were able to communicate energy efficiency in a new way for instance from a baseline of zero up as opposed to top down. It's worthwhile to mention that, the better model is the one which is close to zero before using renewable energy supply (Rocky Mountain Institute, 2012).

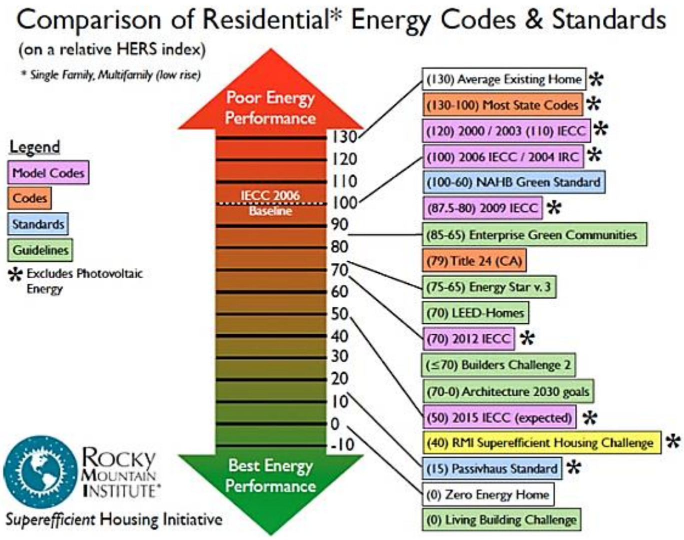


Figure (3.106): Comparison of residential energy codes and standards of relative to HERS Index
Source :(Rocky Mountain Institute, 2012)

3.8. Conclusion:

To sum up, it can be said that, by intentionally conserving all forms of energy and promoting reliance on renewable resources in planning and design choices, communities can simultaneously improve and promote their local sustainable development. This may prove that, the widespread of the economies, environments, as well as the social benefits are mainly due to the integral nature of energy in communities. As the reduction in greenhouse gases that result from more efficient communities help international commitments to mitigate climate change. From another perspective, energy relationships are numerous and complex within neighborhoods elements, as where efficiency gains in one sector lead to related improvements in other sectors. Thus, improving in the energy sector will consequently improve the other sector, such as housing, employment, recreation, travel, as well as infrastructure. It is also worth mentioning that, communities all over the world are reaping the economic and environmental benefits of using energy efficiency strategies as part of their comprehensive planning. Accordingly, the following table represents the energy efficiency checklist which has been extracted as a conclusion from this chapter. This checklist could be used as a base for evaluating the energy efficiency design configurations at any New Settlement. Also, the next chapter contains an overview of some of the different visions and experiences from some examples. This is mainly to prove that the common community planning issues today for efficient energy production, distribution and consumption are almost the base of designing any sustainable neighborhood.

3.9. Checklist for Energy Efficiency:

Design Consideration			
Energy Consumption			
Urban	1. Orientation	Does the main layout concept provide strategies for reduction of energy consumption by considering the site conditions and the climate requirements such as the sun and the wind direction?	☐
		Is the street layout run east and west, while the lots face the north or south, thus maximum benefits of the privilege wind can be gained, as well as the heat gain from the sun can be managed?	☐
		Does the building oriented to the east- west axis, so that its longest elevation is oriented toward the north and the south, thus more daylighting can be gained while controlling the glare?	☐
	2. Wind Direction	Does the building oriented toward the privilege wind, so that it can increase the natural ventilation?	☐
		Does the main layout urban fabric support the concept of the staggered blocks, so that privilege wind can reach each block?	☐
		Does the layout concept design take in consideration the appropriate distribution of building mass, so that make the outdoor climate comfort and breezy?	☐
	3. Solar Radiation	Does the building respect the sun orientation, so that the surface which gains solar heat or solar radiation decreased?	☐
		Does the building's roof used insulation, shading devices, as well as materials with high thermal mass, in order to decrease the solar radiation absorbed?	☐
		Is the urban form is compact, thus buildings can shade each other?	☐
		Does the layout design take in consideration the exterior surrounding elements such as the adjutant buildings and trees, so that more shading areas can be provided which make the outdoor climate breezy?	☐
		Does the layout design take in consideration the proper street proportions (the preferred street width/ height is 1:2), thus in order to reach an efficient solar radiation?	☐
		Does the design promote the concept of unshaded glass areas by preventing the abstractions above them?	☐
	4. The Exterior Environment	Do the exterior elements such as the walls, roofs, pavements, sidewalks, as well as the exposed surfaces of parking lots, have a low heat absorption coefficient, in order to lower the heat island effect?	☐
		Can light-colored (high albedo) surfaces be used for the built form and elevations, in order to reduce the urban heat island effect and thereby lowering the outdoor ambient temperature and reducing cooling loads of adjacent buildings?	☐
		If it is possible to use the reflective paving materials instead of the impervious absorptive one such as using the white cement mixtures or light-colored pavers instead of traditional asphalt paving, so that the heat absorption and heat build-up can be reduced?	☐
		Is the building material is extremely dense with high thermal mass, so that they can absorb heat well?	☐
	5. Water Features	Does the main layout concept provide strategies for using water features such as sprinklers, fountains and lakes, so that they can provide evaporative cooling and increase the potential of natural ventilation?	☐
	6. Block Density	Does the planned population density support the concept of high density compact urban form, in order to reach a district which is protected from solar radiation, reduced the dependence on automobiles and provided shared infrastructure	☐
	7. Landscape	Does the layout design use the soft landscaping elements such as trees, shrubs and vines, to maximize the shading of streets and outdoor spaces for pedestrians?	☐
		Does the layout design use the native vegetation, in order to use less water and provides dust protection to enhance natural ventilation for public areas?	☐
		Does the layout design use the proper type of the soft landscaping elements such as deciduous plants, evergreen trees, as well as the vines, to maximize the shading of building envelope?	☐
	8. Exterior Block Properties	Does the building's form is compact and with a lower ratio, in order to reduce heat gain and losses respectively?	☐
		Is the design of the building's shape seeking to minimize corners and maximize floor area in relation to the outside wall area?	☐
		Is the building mass configuration appropriates the using of the linear mass which offers a useful environment, as well as keeps the energy loads to a minimum?	☐
Architecture	1. Walls	Does the building depend on installing energy-efficient cladding systems in the building, which has a higher thermal resistance and fewer thermal breaks than typical cladding systems, so that less energy is required to heat and cool the building?	☐
		Does the building designed to make use of externally insulated, dense materials like concrete, bricks and other masonry, which they absorb, store and re-release thermal energy?	☐
		Can wall insulation be accommodated, in order to reduce the heating and cooling loads in a building?	☐
		Do the colors for the building's walls are in light color, so that they reduce the absorption of sun's heat, which directly influences the heating and the cooling load of the building, as well as reduces energy demand?	☐
		Does the design take in consideration the orientation of the wall, which consequently influences the exposure to solar radiation?	☐
	2. Roof & Ceiling	Does the building improve the thermal resistance of the roof's material, thus in order to decrease the absorption of the solar radiation?	☐
		Can green roofs be accommodated, in order to lower heat island effect and used as insulation for the indoor climate?	☐
		Does the proper selection of the roof's form decrease the absorption of the solar radiation?	☐
		Does the buildings' roof are well insulated, so that they can minimize the heat gains?	☐
		Does design take into considerations the using of the cool roof systems, which are inherently reflective, light in color, as well as have the ability to achieve some of the highest reflectance and emittance measurements?	☐

Architecture	3. Daylighting	Does the building's mass support the daylight access while limiting the direct solar radiation and the glare?	☐
		Does the building use the proper window dimension and location, in order to achieve the optimal daylighting?	☐
		Does the building' design promote the concept using the skylight strategies such as atrium, clear story openings, as well as solar tube, so that the daylight can penetrate deep inside the building?	☐
	4. Openings	Does the concept of using the suitable glass type is promoted, such as using the double glaze, reflective glass, tinted glass, as well as low emittance coating glass, so that the noise and the heat can be isolated?	☐
		Can the window wall ratio be optimized to match the climate conditions?	☐
		Does the design meet the requirement of the passive house standards which mainly depend on the specific ratio for the U factor, SHGC of the window, in order to reduce heat transfer while enhancing good visible light transfer?	☐
		Can the window type be selected to match the required performance?	☐
		Have the window installed well, thus to ensure that its energy performance is achieved and the window does not contribute to building moisture problems?	☐
		Does the window opening are well-placed and their dimensions are well-calculated, so that they can balance the interior lighting requirements?	☐
	5. Insulations	Do the windows, roofs, as well as walls are well insulated, in order to prevent energy waste as well as improve the indoor thermal comfort?	☐
		Does the design well select the proper type of the insulation material, so that slow the rate of the heat transfers?	☐
		Do the design strategies for insulation promoted the using of high R-value, in order to resist the transfer of heat flow?	☐
	6. Shading Devices	Does the building's design take in consideration the using of shading devices for windows, so that it can create pleasant outdoor and indoor spaces?	☐
		Does the design well selected the proper type of the shading device that can be used, such as the fixed louvers, light shelves, as well as overhangs and side fins?	☐
		Does the design use the proper direction of the shading devices such as the vertical or the horizontal direction, so that it becomes effective according to the building elevation?	☐
		Does the building use the proper dimension of the shading devices?	☐
	7. Natural Ventilation Systems	Does the building use the ventilation strategies such as the cross ventilation, the stack effect, as well as the wind catcher, so that it can reduce the cooling load?	☐
		Does the inlet and the outlet are well-placed and their dimensions are well-calculated, so that they can enhance the natural ventilation?	☐
		Does the design use building's form with a narrow shape around 15 meters maximum, so that encourage the cross ventilation inside the building?	☐
		Does the building designed around the atrium or the courtyard, in order to optimize natural ventilation access?	☐
Energy Distribution			
Urban	1. Smart Grids	Is the project promoting the concept of the smart grid, so that electricity can be delivered more cost effectively, with lower impact on the environment?	☐
		Is the energy distribution grid infrastructure becoming modernized enough to support the concept of the integration of decentralized green energy sources?	☐
		Does the system equipped with sensors, two-way communications, smart meters, advanced control devices and new visualization tools, which will give the grid operators the tools they need to reduce distribution losses and improve asset utilization, thereby reducing the generation capacity and production needed to serve a given load?	☐
Architecture	2. Smart Home	Is the home equipped with smart appliances such as the smart refrigerator conditioner, smart dishwasher, as well as the smart plug-in electric vehicle, so that they can be networked together, allowing the resident to access and operate them through the energy management system?	☐
		Is the home equipped with smart meters, which can operate digitally and allow for automated and complex transfers of information between home and its energy provider?	☐
		Is the home design promoting the concept of using an energy management system which is a computerized system that attempts to allow the resident to choose settings that allow specific appliances and equipment to turn off automatically when a large demand threatens, so that this is consequently helping to balance the energy load and preventing blackouts?	☐
Energy Generation			
Off-Site	1. Off-site Biomass / Biogas plant	Is the project promoting the concept of generating energy from burning the biological material such as landfills products and wood products in an off-site boiler, which then produces heat and energy to be used by the buildings?	☐
	2. Solar Farms	Is the project depending on the solar farms as a source of energy to power the grid instead the energy produced from the fossil fuels?	☐
	3. Wind Farms	Is the grid connected with wind farms either offshore or onshore to be as a source for distrusted clean renewable energy source, which produce no greenhouse gas emissions during operation?	☐
On-Site	1. Photovoltaic systems	Does photovoltaic panels are integrated and installed within the building envelope as a renewable energy system?	☐
		Do the panels placed and insulated in the suitable location which help to achieve the maximum efficiency of the panels?	☐
	2. Solar water heaters	Have solar water heaters installed as a renewable energy system, which can be used to provide domestic hot water?	☐
	3. Geothermal	Is the building taking the advantage of the consistent temperature found below the Earth's surface and uses it to heat and cool buildings by applying the geothermal heat pump systems?	☐
	4. Biomass / Biogas	Is the project promoting the concept of generating energy from burning the waste products such as the wood products in an on-site boiler, which then produces heat and energy to be used by the buildings?	☐
	5. On-site Turbines	Are the outdoor spaces and the buildings can be a base for mini wind turbines, which can be integrated into the built environments planning and design?	☐

Table (3.8): Energy Efficiency Checklist
Source: Adapted by the author

4. Chapter Four: Applications

4.1. Introduction

4.2. Model City Case Studies

4.3. Criteria for Selection of the Examples

4.4. BedZED (Sutton, UK)

4.5. Masdar City (Abu Dhabi, United Arab Emirates)

4.6. Wilhelmsburg (Hamburg, Germany)

4.7. El Gouna (Hurghada, Egypt)

4.8. Conclusion

4.1. Introduction:

This chapter aimed to explore the key issues related to the applications of sustainability in practice. It examined a number of projects, which attempted to develop principles of sustainability on various scales, even on the global scale and the national scale. The aim of this part is not to evaluate the principles of sustainability individually, but rather to provide practical examples of the different approaches and frameworks used for applying the sustainability principles. On the other hand, to highlight the advantages and disadvantages of such kind of projects and conclude the general common lessons from them.

4.2. Model City Case Studies:

As mentioned before that, the rapidly increasing population and trends of urbanization in many world regions today, call for more sustainable forms of development. It is worth mentioning that, many of the city planners, politicians and even environmental groups, have realized the challenges of changing the existing community into the fully integrated sustainable community (Ekblaw et al., 2009). To accommodate with these challenges, there are new trends all over the world have been emerged, such as the green cities, sustainable cities as well as the ecocities (Heinze & Voss, 2009). Besides, much work has been carried out by various organizations and institutions to create various communities, that often make efficient use and integrate the technologically building design with the renewable energy sources, in order to achieve energy self-sufficiency (Heinze & Voss, 2009).

From another perspective, it is worthwhile to mention that, investigating number of those projects indicated that there are common phases included in such kinds of projects. In general, those projects can mainly be applied to two types of cities, the first one is the model cities that are built from the ground up, while the second one is the existing cities that were not originally planned as sustainable cities but are making progress to decrease their impacts on the environment. It is worthwhile to consider that, the new cities are often designed by an urban planning firm that attempts to apply all of the latest technologies in order to create the most sustainable city possible. These cities are serving as large experiments for the various technologies that are incorporated into the cities, while also serving as model cities for others to consider for future implementation. On the other hand, the existing cities around the world are recognizing the need to adopt sustainable strategies to be global leaders. Some cities lag in their efforts while others are implementing large scale initiatives and emerging as internationally-recognized green cities (Ekblaw et al., 2009). However, to what extent these projects succeeded in fulfilling the main purposes for which they have been established and what are the drawbacks of their practical implementations, are what this chapter attempts to investigate.

4.3. Selection Criteria of the Examples:

To narrow the scope of selection, many criteria have been identified to be determined in the practical examples as follows:

- The first example was taken to examine the notion of model city which seek to create more sustainable living environments and minimize the residents' ecological impacts.
- A leading example, or a mega project, which aimed to set new benchmarks for achieving zero energy community or the CO^2 neutral balance. The example should represent a model city or a test-bed, in order to help in learning how to build zero energy cities globally.
- An example of an existing city that was not originally planned as sustainable one, but was making progress to decrease its impacts on the environment.
- An example of an existing district, that already affected by the problem of the climate change and tried to demonstrate solutions for the largely urban built-up environment which fulfills all the energy requirements by renewables.

According to the previous criteria, the study samples included 4 projects: 3 of them are international examples, while one is national example, to assess progress on the path of sustainable development, as shown in figure (3-1).

Figure (4.1): The location of the examples
Source: (MOS, 2012) adapted by the author

The chapter first examined the notion of model cities by discussing two relevant case studies such as BedZED and Masdar City before investigating the ways that existing cities such as El Gouna and Wilhelmsburg were applied to incorporate sustainable practices into their urban development. Figure (3.2) shows the kind and the cause of the selection of the selected examples. It's worth mentioning that, in the analysis of the case studies, the researcher used structure steps in order to facilitate the comparison between them. The points that will be discussed in each example are evaluated in two scales; the first one illustrates many considerations necessary to fully evaluate the sustainability and feasibility of development in general. The second one evaluates in details the principles that are necessary to achieve the energy efficiency in particular. All of these design principles have been extracted from the literature review parts (Chapter 1 and 2).

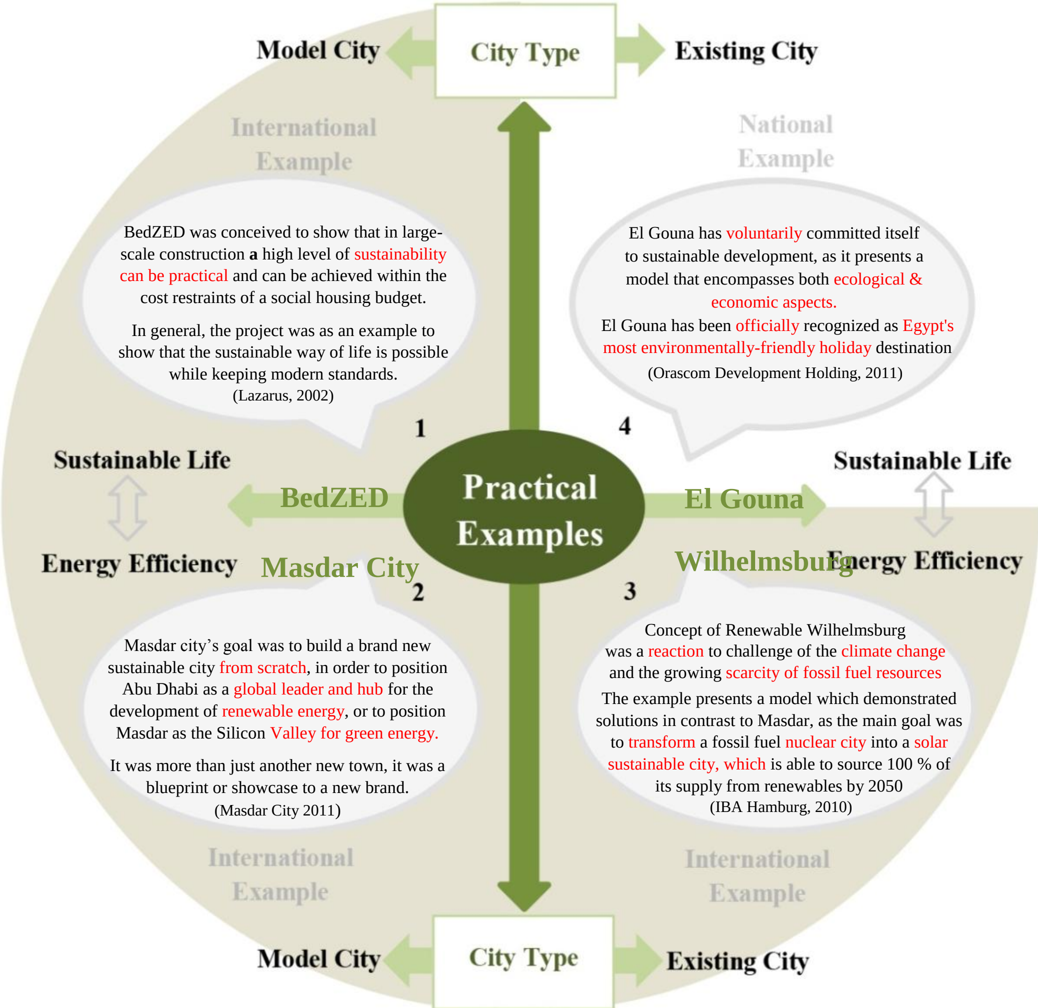


Figure (4.2): The kind and the cause of the selection of the examples
Source: adapted by the author

4.4. <u>BedZED (Sutton, UK):</u>

BedZED was designed as a model of sustainable development to show the ways of decreasing the environmental damage to the urban housing of the future. The project was as an example to show that, a sustainable way of life is possible while keeping modern standards. In general, its skill lies in the way it brings together a number of proven methods, none of them have particularly high tech for reducing energy, water and car use (Lazarus, 2002 & Hodge et, al, 2009).

- <u>Background & Overview:</u>

BedZED (Beddington Zero Energy Development) is the UK's first and largest carbon neutral eco-community in the UK. The planning has begun at 1999 and completed in 2002 (Lazarus, 2002). It's worth mentioning that, the site was a brown field property close to existing commuter rail lines, it is located in Sutton, 40 minutes South-East from London. It is a mixed-use scheme initiated by BioRegional Development Group and Bill Dunster Architects (Ghosh & Gabe, 2007). The mixed-use scheme comprises 82 mixed tenure homes, plus some 3000 m2 of live/work, workspaces, retail and leisure uses, as shown in figure (4.3) (Twinn, 2003).

Figure (4.3): BedZED
Source: (Ghosh & Gabe, 2007)

- <u>BedZED Vision:</u>

According to the study done by Twinn (2003) demonstrated that, the BioRegional were working to show that eco-construction and developing green lifestyles can be easy, accessible and affordable. It's worth mentioning that, BedZED offers solutions to many sustainability lifestyle issues in a practical and replicable way (Lazarus, 2002). One key reason for embarking on the BedZED project, was to demonstrate a project which could show how sustainability is possible in the future and how can be cost effective. In general, it was designed to minimize its ecological impacts both in the construction and operation, as well as to help residents live within their fair share of the earth's resources without sacrificing the modern urban lifestyle (Hodge et, al, 2009).

- <u>BedZED Vision towards Sustainable Development:</u>

It was conceived to show the sustainable development in large scale construction. BedZED's aimed to prove that, the higher level of sustainability can be practical and can be achieved within the cost restraints of a social housing budget (Lazarus, 2002). It is also worth mentioning that, the city has been planned to exceed the requirements of the 10 sustainability principles of the BioRegional One Plant Living framework (Hodge et al., 2009). BedZED's approach mainly encouraged the concept of the sustainability, which mainly depends on any overall effect on the environment, economic and social objectives, in order to benefit all stakeholders, as shown in figure (3.2) (Twinn, 2003).

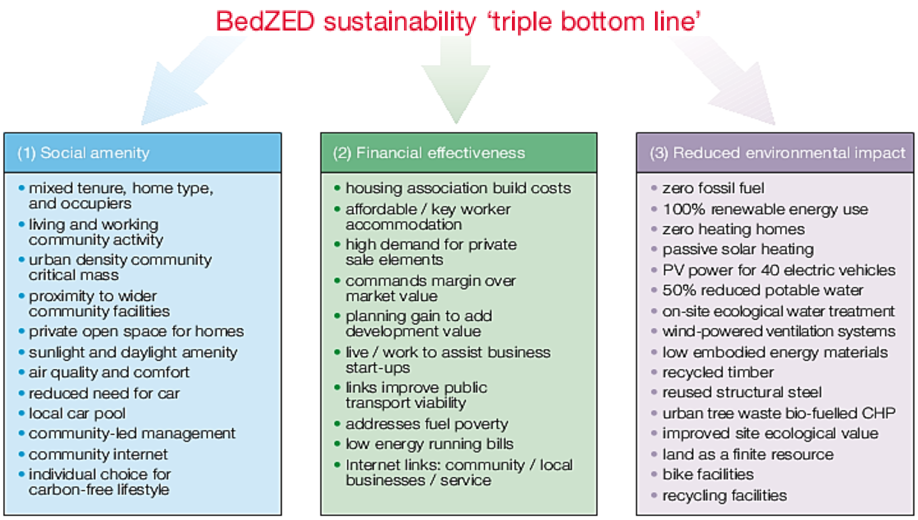


Figure (4.4) : BedZED sustainability approach
Source: (Twinn, 2003)

- <u>Environmental Aspect:</u>

The main driving factor of the BedZED project was environmental base. BedZED was thought to reduce environmental impacts at every level home, including construction, energy, food, work, transports, as well as social life (Ghosh & Gabe, 2007). The BioRegional Development Group targeted to reduce the residents' ecological footprints by two-thirds than the normal. It is worth mentioning, that the design was eliminating the need for space heating and was reducing water consumption by a third. In addition to that, it was facilitating the concept of reducing waste to landfill, recycling waste and reducing car use (Lazarus, 2002). A brief description of how BedZED meets the goals for environmentally sustainable communities was explained in the following part.

1. <u>Land-Use System:</u> The project integrated all aspects of city life, in which the 82 homes and 1,600m2 workspace at BedZED were supported by facilities including sports pitch, clubhouse and possibly local childcare facilities. In addition to, shops and cafes were planned for the site. Figure (4.5) shows the integration of all the facilities within the site (Twinn, 2003). It is worth mentioning that, the integration of work spaces in the project allowed people to work closer to their homes, which consequently reduce the carbon emissions of transportation. On the other hand, the integration also encouraged the development of diverse neighborhood which contribute the daily activities to the site (Lazarus, 2002). However, the negative side that the community is not large enough to provide large public services such as schools and medical centers (Hodge et, al, 2009).

Figure (4.5): BedZED master plan
Source: (Twinn, 2003)

2. <u>Waste Management:</u> BedZED' aims to reduce waste and encourage recycling on-site, the target is about 60% recycling rate by weight of the waste. Ideally BedZED residents would have door-to-door waste collection services (Ghosh & Gabe, 2007). Besides, the project has bins for different materials around the perimeter of the site, such as separate bins for each of papers, cards, steel, aluminium cans, as well as glasses. It's also worthwhile to consider that, all items are treated on-site rather than being collected by the local authority. This would save energy in transportation and reduce the volume of

materials to be processed by the council's waste contractors (Lazarus, 2002). While on the other side, the study by Hodge et al. (2009) showed that, despite the signs on the bins and the information on the residents manual and newsletters, it seemed that some residents are still unaware of what can be recycled on-site.

3. Mobility System: The Green Transport Plan at BedZED has three strands which were mainly based on: reducing the need to travel, promoting public transport and offering alternatives to private car travel. The main aim was to reduce the private fossil fuel car mileage by 50% of what would have been expected of a conventional build on the same site (Lazarus, 2002). It's worth mentioning that, the provision of facilities like shops, schools and public transport is viable within convenient five minutes walking. The project also provided a cycle network, besides the secure cycle storage and repair facilities which are provided on-site (Hodge et al., 2009). On the other hand, the project also has limited parking space and they mainly placed at the edge of the community, in order to leave the center areas pedestrianized only. In addition to that, a good public transport links are provided, which include two railway stations, two bus routes and a tram link. Furthermore, residents will also be encouraged to change to an electric vehicle (Twinn, 2003& Ghosh and Gabe, 2007). It is stated by Hodge et al. (2009) that, BedZED was the first low car development in the UK to incorporate a car club which is provided by city car club and also the first to encourage the car pool displaces, which is four to five privately owned one vehicle.

4. Water Management: BedZED sought to reduce the treated potable water demand by more than 50% than conventional housing. It also sought to treat all of the site's wastewater, so that the resulting green water effluent could be reused to flush toilets and irrigate gardens (Ghosh & Gabe, 2007). This system combined with rain water harvesting, which has saved another 15 liters of mains water per person per day. Actually, the rainwater was collected from roof surfaces and stored in underground tanks for irrigation and toilet flushing, as shown in figure (4.6). Although the rain water is not currently being reused on-site, it is reverting to the ground water (Hodge et al., 2009). Besides, another various best practices have also been incorporated, including restrictions to prevent excess flows, mains pressure showers to avoid power showers, meters visible to consumers, as well as using water-consuming appliances such as the dual flush toilets to save water (Lazarus, 2002).

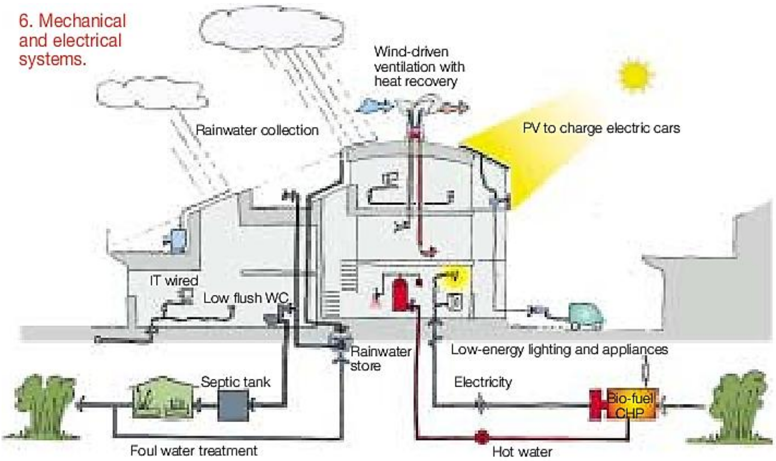


Figure (4.6): BedZED rainwater and recycled water use system
Source: (Ghosh & Gabe, 2007)

5. Food System: At BedZED residents were encouraged to grow their own food and promoted organic fruit and vegetable box delivery schemes, that in order to address the impacts of local production for local needs (Twinn, 2003). Many projects can be done to address this aspect, among those projects is a food-growing project, which will be established as part of the proposed adjacent ecology park. Besides, all residents were encouraged to grow food in their sunspaces and on their roof gardens, with a free selection of vegetable and seeds. On the other hand, the food shops were encouraged to sell local products (Hodge et al., 2009).

6. Materials Conservation: It is stated by Twinn (2003) that, BedZED's local sourcing policy was able to source 52% of the materials from within the target 35 mile radius. By adopting the 35 mile radius, BedZED ensured that it respected the local market conditions, as well as used all the local materials which have less embodied energy and cost. In addition to that, 15% of the materials used were reclaimed or recycled (Ghosh &Gabe, 2007).

7. Natural Systems: BedZED has aimed to provide the best possible habitat for biodiversity in the urban environment through implemented a number of measures such as using the native plants which encourage particular species in the roof gardens and all site landscaping (Hodge et al., 2009). Besides, the features of the buildings have been designed to encourage wildlife such as incorporating bat roosts into the weatherboarding (Twinn, 2003). In addition to, feeding and nesting stations to encourage tree sparrows and Sedum planted roofs to provide an insect habitat, which in

turn supports birdlife. Besides, the BedZED Biodiversity Plan will be complemented by the ecology park, which will be established on the adjacent site (Ghosh &Gabe, 2007).

8. Housing: BedZED showed that an eco-friendly lifestyle can be easy, affordable and attractive. The community incorporates a range of housing types and sizes, as well as 18 gallery mews apartments and commercial facilities resulting in diverse, safe and socially active places to live. It is stated by Hodge et al. (2009) that, a third of the housing was dedicated to low income rental units and outright ownership making up the other two-thirds. This mix of homes for sale and rent in subsidized and market terms, will attract high and low income. This is mainly the basis of any socially inclusive communities. Also, it's worth mention that, the project includes two-thirds of affordable or social housing, this high proportion of affordable housing will ensure a variety of different income brackets and professions live at BedZED (Ghosh &Gabe, 2007). On the other side, the mix of sizes from small flats to four bedroom town houses allows a range of age groups, single people and families move in (Twinn, 2003).

9. Energy Efficiency: BedZED design concept was driven by the desire to create a net zero fossil energy development. The development was therefore a carbon neutral development resulted in no net addition of carbon dioxide to the atmosphere. BedZED aimed to be a community that produces at least as much energy from renewable sources as it consumes (Twinn, 2003 & Hodge et al., 2009). The earliest concepts for the project centered on the idea of home energy autonomy, with each dwelling operating solely on the ambient energy which it could harvest from its own site. This led to the energy consuming systems in the dwelling being reduced enough to match the energy harvested from solar photovoltaic panels, thermal collectors and small wind turbines. However, in cost terms this was not viable within the current cost yardsticks and so the thinking turned to wider local community autonomy, which eventually identifying bio-fuelled CHP as a potential solution (Ghosh &Gabe, 2007).

9.1. Energy Consumption: The strategy for reducing energy consumption at BedZED included plans for reducing or eliminating space heating demand by providing passive solar design. It's worth mentioning that, the strategy aimed to reach the 60 % reduction of the total energy demand compared to the average British households, 90% reduction of the heating need, as well as a 50% reduction in energy bills are predicted (Ghosh &Gabe, 2007).

9.1.1. Urban Scale:

I. Orientation: According to the site analysis, different orientations for the varying building uses of homes and workspaces were provided. These workspaces are thus best oriented north, in order to maximize natural daylight, which consequently reduced the need for daytime artificial lighting, as well as avoided the excess solar heat gain. On the other side, homes faced south, in order to gain useful benefit from the supplementary solar heat gain. It's worthwhile to mention that, this orientation is the best according to their climatic conditions. As it is widely known that, the homes in this region are preferred to be oriented south to take the privilege of the solar radiation. In addition to that the design used extra sun space areas in the south, in order to gain more solar radiations in homes, as shown in figure (4.7) (Twinn, 2003).

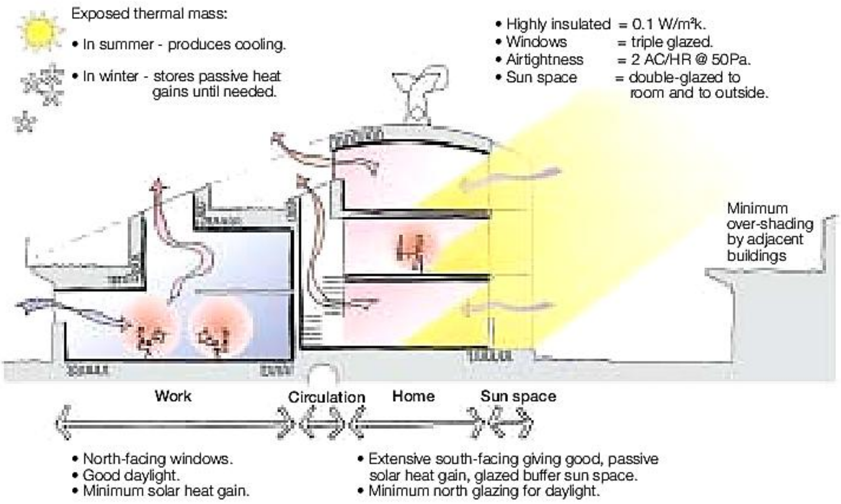


Figure (4.7): Shows the effect of the good orientation in BedZED
Source: (Twinn, 2003)

II. Wind Direction and Velocity: The majority of the buildings lay in the direction of the privileges wind, besides the design added active system inside the buildings to help the buildings to achieve certifiable ventilation and heat recovery performance (Twinn, 2003 & Lazarus, 2002).

III. The Exterior Environment: All earthworks for landscaping were done using the on-site excavated material. Among those materials were the crushed concrete, which was used instead of fresh aggregate as road sub-base. On the other hand, paving slabs were bedded in recycled crushed green glass, which was used instead of virgin sand. These recycled products are mainly helped in reducing energy consumption (Lazarus, 2002).

IV. Solar Radiation: It's worth mention that, the buildings were oriented for passive solar gain and employ high levels of thermal mass. They also used high super insulation to prevent overheating in summer and store warmth in winter (Lazarus, 2002). BedZED houses are arranged in south facing terraces to maximize heat gain from the sun, each terrace is backed by north facing offices, where minimal solar gain reduced the tendency to overheat and the need for air conditioning, as shown in figure (4.8) (Twinn, 2003).

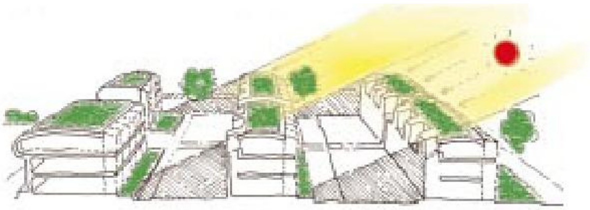


Figure (4.8): BedZED's buildings are oriented for passive solar gain
Source: ((Lazarus, 2002)

V. Block Density: The project chosen high build-density within a three-storey height restriction. It reflected the importance of using limited land resources to the full, while allowing the massing and orientation needed for good passive solar and daylight access. Such high density helped in building coherent community which provides a critical mass for facilities like public transport (Twinn, 2003).

VI. Landscape: The project mainly included over 4000 m^2 of green open space per Hectare. Besides, the project incorporated private gardens for the 82 units. These are in the form of roof gardens on top of the workspaces for the flats and ground-level gardens of the houses and maisonettes. These gardens from small outdoor rooms and vary in size from 8 m^2 to 25 m^2, while most of the roof gardens at 16 m^2 (Twinn, 2003). On the other hand, the project also established an eco-park with an area 18-hectare of the adjacent site (Ghosh &Gabe, 2007). In general, all the landscaping elements for the development made use of native species plants, in order to help in providing habitat for local ecology (Lazarus, 2002).

VII. Water Features: According the master plan, it was obvious that, there were no water features within the boundary of the site.

VIII. Exterior Block Properties: It is worthwhile to mention that, the mass of the building was well designed. As its previously mentioned that, the buildings' mass have been designed in order to make the most of fresh prevailing winds across the buildings by using the wind cowl ventilation systems (Twinn, 2003). On the other side, the exterior material of the building envelope was well selected, as it is previously mentioned that they used the solar sun space in the south to gain more solar radiation. Besides, in the building's construction super insulated heavy masonry was used, which consequently help in decreasing the energy consumption within the building (Lazarus, 2002).

9.1.2. Architectural Scale: Next most effective is the building performance optimization, such as an efficient envelope and systems, as well as smart building management. For BedZED, the main target was to decrease the electricity for lighting, cooking and all appliances by 55% less than conventional housing. In achieving this energy efficient carbon neutral design, BedZED invests in more well designed houses than standard houses (Lazarus, 2002 & Ghosh and Gabe, 2007). The building physics that achieves zero space heating requirements in the south facing homes was depended on some techniques used in the building elements such as:

I. Walls: It is stated by Ghosh & Gabe, (2007) that, the material choices in the building envelope were largely decided by the thermal requirements of the BedZED design. Buildings were constructed from heavy weight materials with high thermal inertia that can store heat during warm periods and radiate warmth during cooler periods. On the other hand, the concrete blocks and concrete floors which provided high thermal mass with very stable thermal environment which avoided large temperature fluctuations. All of these features worked to greatly reduce the heating need in the commercial, live and work areas (Lazarus, 2002).

II. Roof & Ceiling: Two types of roofs were used, the first was the high curved roof that has no regular access, as shown in figure (4.9). While the second was the green roofs which planted with a low maintenance Sedum mat, as shown in figure (4.10). Those green roofs consisted of a root resistant bitumen membrane laid on the concrete roof slab, then a polyethylene foil layer. Then a 300mm expanded polystyrene insulation board was overlain with a mineral fiber growing medium. Making the roof areas green helped in increasing the site's ecological value and its carbon absorbing ability. As well as, they gave the occupants the ability to use their private gardens (Lazarus, 2002 & Twinn, 2003).

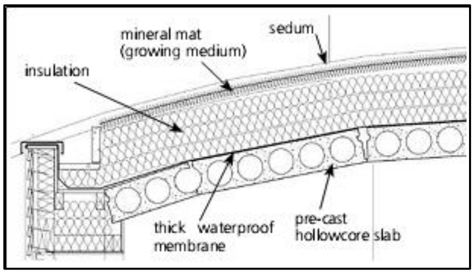


Figure (4.9): Sedum roof used in BedZED
Source: (Lazarus, 2002)

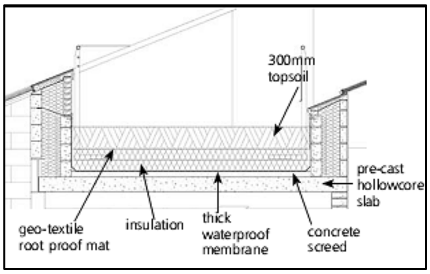


Figure (4.10): Grass turfed sky garden roofs used in BedZED
Source: (Lazarus, 2002)

III. Openings: All windows were either double or triple glazed. Timber frame windows were chosen over aluminium or UPVC for embodied energy and environmental impact reasons (Lazarus, 2002).

IV. Insulation: Another energy saving technique that BedZed incorporated, was the use of airtight construction methods. It is stated by Lazarus (2002) that, all of the buildings were super insulated and have south facing glazing to provide useful heat gains in the winter. The high levels of insulation greatly reduced heat losses through the building fabric. It's worth mentioning that, the air permeability results at BedZed, are down to 2-3 cubic meters per hour per square meter of external surface at 50pa differential pressure. However, the typical UK building requirements state that air permeability is not to exceed 10 cubic meters per hour per square meter of external surface at an applied pressure difference of 50pa (Ghosh & Gabe, 2007).

V. Natural Ventilation System: The project depended on using passive stack ventilation system. All BedZED buildings used the wind cowls which depend on the positive and the negative wind pressures, in order to deliver supply air and extract vitiated air. The wind cowls also generated enough pressure for the air to be ducted down into the buildings, delivering their preheated air to each living room and bedroom and extracting air from each kitchen, bathroom and toilet, as shown in figure (4.11) (Twinn, 2003& Ghosh and Gabe, 2007).

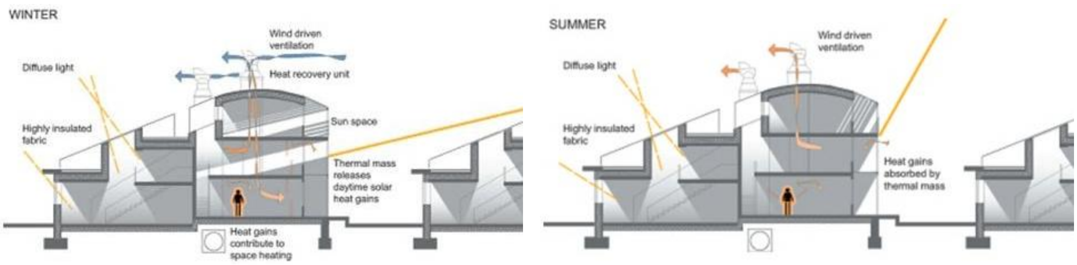


Figure (4.11): Wind cowls work enhance the ventilation within the building
Source: (Ziger/Snead Architects, 2007)

VI. <u>Daylighting Techniques:</u> It is worth mentioning that, the idea of the project in general is based on illuminating the buildings through roof lights. Those roof lights were triple glazed with aluminium frames, as shown in figure (4.12) (Lazarus, 2002).

Figure (4.12): Roof lights used in BedZED
Source: (Lazarus, 2002)

VII. <u>Shading Devices:</u> It's worth mention that, the project aimed to maximize heat gain from the sun in BedZED houses, also minimize solar gain in the north facing offices, in order to reduce the tendency to overheat and the need for air conditioning. The well designed master plan can effectively achieve this concept without the need to shading device in the design, as the design minimized the over shading by the adjacent buildings and the street below (Lazarus, 2002 & Twinn, 2003).

9.2. <u>Energy Distribution:</u> The earliest concepts for BedZED centered on the idea of home energy autonomy and tried to influence residents energy use behavior by having the meters on the show (Ghosh & Gabe, 2007). In the selected project, there is information and communications technology (ICT) network, which is a computer-based system, allows such functions as remote reading and billing of electricity, heat and water meters. The ICT cable routes were intended to be fully rewireable, so they can respond to future changing requirements (Twinn, 2003).

9.3. <u>Energy Generation</u>: Simply, the zero carbon strategy was to reduce energy demand in the buildings for example through: insulation and air tightness, fitting homes with low energy appliances and tried to influence residents energy use behavior by having the meters on the show (Lazarus, 2002). Then, supply the remainder of the energy required by renewable energy on-site. Actually BedZED designed to show a workable renewable energy strategy for communities of a similar scale in a similar type of suburban location (Hodge et, al., 2009).

- **<u>Off-site Renewables:</u>** BedZED meet all its energy demands from renewable, carbon neutral sources which generated on-site, in order to eliminate about 29% contribution of CO^2 emissions and global warming (Hodge et, al., 2009).

- **<u>On-site Renewables:</u>** At BedZED the idea was to meet all the energy need with on-site technologies (Ghosh &Gabe, 2007). Among those on-site technologies are:

1. <u>Biomass: Bio-fuelled combined heat and power (CHP):</u> BedZED received power, heat and hot water from a small, locally placed CHP plant, which is powered by off-cuts from tree surgery waste that would otherwise go to landfill, as shown in figure(4.13). The CHP plant utilizes the heat produced as a by-product of generating electricity. It's worth mentioning that, those plants are considered carbon neutral because the amount of carbon released during combustion is equal to the amount that has been absorbed over a tree's lifetime and thus no new carbon is being released into the atmosphere (Hodge et, al., 2009). Nowadays, this is not currently in operation, according to main technical problems. This consequently led to make the hot water demand produced by a gas condensing boiler and the electricity supplied from the national grid with a proportion of renewable electricity being generated on-site by photovoltaic panels. Thus, a great work has been done, in order to identify a replacement for this unit to maintain the concept of to a zero carbon development (Lazarus, 2002& Twinn, 2003).

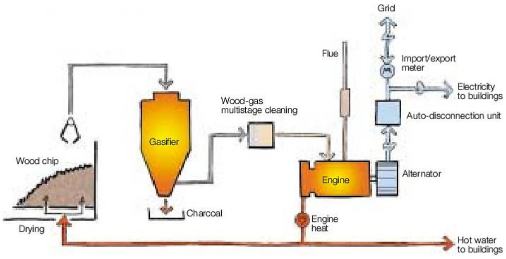


Figure (4.13): Bio- fuelled combined heat and power used in BedZED
Source: (Twinn, 2003)

3. <u>Photovoltaic:</u> BedZED's 10-year target is to produce enough electricity from photovoltaic panels to power 40 electric vehicles for 10,000 annual miles each. It's worth mentioning that, the panels were not only add-ons, but also well integrated in the structure of south facing facades, as shown in figure (4.14) (Hodge et, al., 2009 & Ghosh and Gabe, 2007). On the other side, the study by Twinn (2003) demonstrated that, the concept of using the PV panels for powering the buildings was originally discarded because its capital cost is too high to recover through savings in relatively cheap mains electricity. Although, the buildings were still future-proofed to accept solar collectors on their southern façades in anticipation of when PV costs reduce. Given that the buildings had been already carbon neutral with the bio-fuelled CHP. This means that, those panels designed only to promote the idea of the service to create carbon neutral transport, but after the CHP stoped working they becomes using their energy to meet home electricity (Ghosh & Gabe, 2007).

Figure (4.14): The integrated PV panels used in BedZED's buildings
Source: (Telegraph Media Group, 2013)

- **<u>Observation on BedZED:</u>**

Rarely do the full range of parties come together to deliver a complete example project without compromise. Accordingly, there are some positive and negative points should be mentioned within that project. Among those points are:

- <u>Pros:</u> BedZED encouraged the sustainable lifestyle strategies with a very cost effective way, in order to reduce the negative impacts compared to the expensive infrastructure (Hodge et, al, 2009). It also proved that, there is market demand for this kind of projects, in which the mainstream developers and construction participants feel that they can seriously take steps towards a more sustainable world (Twinn, 2003).

- <u>Cons:</u> On the other side, there are numerous negative aspects that mainly determined based on the current operating conditions. Among those aspects are:

1. Some energy experts demonstrated that, there are numerous planning flaws within planning the city. Among these flaws is the design of the BedZED's CHP plant. The plant was operational for long periods, but it does not work today. This may be returned to the reason that, it is too small scale to justify the maintenance needed to keep it operating (Hodge et, al, 2009). Nowadays, the hot water is provided by a district heating system which using a natural gas boiler. Thus, there is a big need to replace the CH plant with an alternative system, that will maintain the concept of a zero carbon development (Twinn, 2003).
2. The photovoltaics panels are originally designed to power the electric vehicles, while the homes are originally designed to be powered by the CHP plant. After the CHP stoped working the panels becomes used their energy to meet the home's electricity. Thus, extra recharging infrastructure off-site should be further advanced by the time to meet the demand of the electric vehicles instead of the panels integrated within the building shells (Twinn, 2003).
3. Another concern is that, a good way of communicating with the residents, needs to be found. As despite the signs on bins, the information in the residents manual and the newsletters, it seems that some residents are still unaware of what can be recycled on-site (Hodge et, al, 2009).
4. Another criticism is that, the community is not large enough to provide public services and capital investment. This consequently led to increase the daily transit outside the community, which negatively impact the environment. Thus, the results showed that, if the BioRegional Development Group develop the community to be large enough to support the local infrastructure such as medical centers and schools and be built according to one planet living standards, this can effectively decrease the ecological footprints of the community (Hodge et, al, 2009).

- <u>The overall ability of the city to succeed:</u>

Although, all the measures of the consumption in the homes are much lower than the average current UK benchmarks, the residents living at BedZED are still unable to get to one planet living level. As it is important to note that, the CHP plant should be replaced in order to achieve CO^2 development, also some public services need to be established around the site to reduce the daily transit. In general, the learned lessons showed that, BedZED has been a success and has been considered as a model show in the workable renewable energy strategy for communities of a similar scale in a similar type of suburban location (Twinn, 2003& Hodge et, al, 2009).

4.5. Masdar City (Abu Dhabi, United Arab Emirates)

Abu Dhabi has always been known as a global energy player, it has traditionally played a leading role in the global energy markets as a significant hydrocarbon producer. Nowadays, the Emirate is concentrating on the economic diversification programs, in order to reduce its dependence on oil and gas. According to Khaled Awad statement, who is one of the directors of the project, he said that "Abu Dhabi is an oil-exporting country, which they want it to become an energy-exporting country". Thus, it is now widely recognized that through Masdar, Abu Dhabi seeks to leverage its substantial resources and experience in this sector to maintain its leadership position in an evolving world energy market. In general, Masdar is increasingly looking to be an international hub for renewable energy, in order to balance its strong hydrocarbon position (A Mubadala Company, 2010 & Leech, 2013).

- Background & Overview:

Masdar City is a carbon neutral city with total size area 7 km^2. It was being constructed 17 km from the city of Abu Dhabi in the United Arab Emirates. It is worth mentioning that, the construction of it began in April 2007 and it was estimated to be completed in 2015. It was designed in two squares with a total population 90,000, in which residents represent 50,000 and commuters represent 40,000, as shown in figure (4.15). It is a mixed used project, in which 30% is zoned for housing, 24% of the business and research districts, 13% for commercial purposes (Masdar City, 2011).

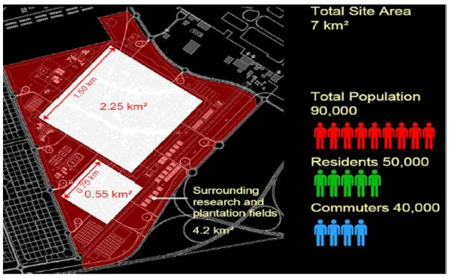


Figure (4.15): Shows that Masdar City is designed into two squares
Source: (Masdar City, 2011)

- Masdar Vision:

It is worth mentioning that, Masdar City is an Eco-city in the desert, which it will be the world's first zero carbon, zero waste and zero car city. It has been designed from scratch as an ecological city that is only dependent on renewable energy (Beglinger & Siegel, 2010). According to the study by Ekblaw et al. (2009) which demonstrated that, the major advantage for building an entirely new city is the ability to apply the latest technologies and materials, in order to decrease the impacts of the city on the environment as possible. It was obvious in the study done by Tompkins (2009)that, the environmental sustainability and the impacts of every aspect of the Masdar City was carefully considered from the initial planning and construction stages to the eventual daily functions of the city. The city serves as a showcase for unconventional planning methods and renewable energy technologies, that other communities might find difficult to implement. This mainly according to the statement of the architect Norman Foster, as he said that "Masdar promises to set new benchmarks for the sustainable city of the future". In general, it is more than just another a new town, but it is a blueprint to show how the future may look like. (A Mubadala Company, 2010 & Leech, 2013). Consequently, the mission of the city can be summarized in four points, as shown in fig (4.16) (Zaafrani, 2010).

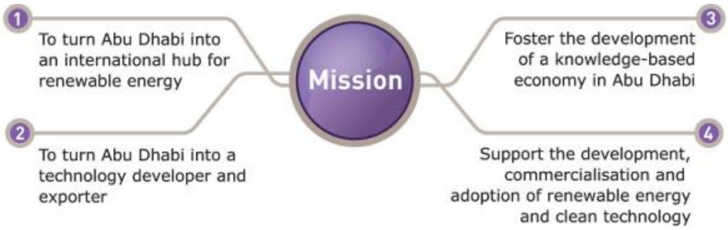


Figure (4.16): Shows the mission of Masdar City
Source: (Zaafrani, 2010)

- <u>Masdar Vision towards Sustainable Development</u>**:**

Masdar City in Abu Dhabi was developed to become a new approach of defining sustainable urban development. The project can be specialized by setting new global standards in sustainable development, it will lead the world to understand how all future cities should be built sustainably (Stilwell & Lindabury, 2008). As the director of Masdar City, Mr Mallows said that: they were not only trying to build simply the world's most sustainable city, but they were trying to build the world's most sustainable city as a model and as a test-bed (A Mubadala Company, 2010). It is worth mentioning that, the city has been planned to exceed the requirements of the 10 sustainability principles, which are the base of the BioRegional One Plant Living framework, as shown in figure (4.17). Among those principles are: zero carbon, zero waste, sustainable transport, sustainable materials, sustainable food, sustainable water, habitats and wildlife, culture and heritage, equity and fair trade, as well as health and happiness (Falconer, 2008).

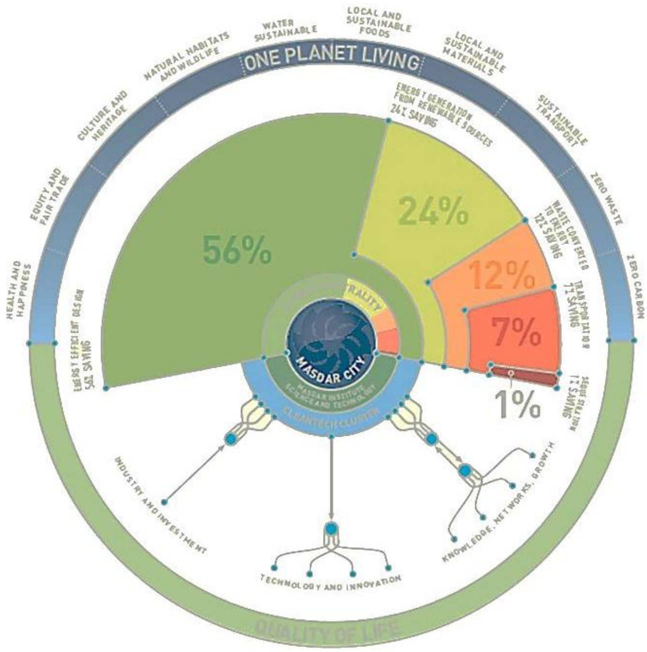


Figure (4.17): Masdar City is implementing the " one planet living" sustainability strategy
Source: (Falconer, 2008)

- Environmental Aspect:

One of Masdar's greatest strengths is its environmental sustainability components. In fact, compared to the average urban city, Masdar City can employ the most cutting edge renewable technologies and sustainable design elements which vastly reduce Masdar's ecological footprint. Figure (4.18) shows the main differences between the design of the conventional city and the design of Masdar City (Masdar –Abu Dhabi future company, 2010). The following part provides a brief description of how the city meets or exceeds each of the One Planet Living initiative's goals for environmentally sustainable communities (Stilwell & Lindabury, 2008).

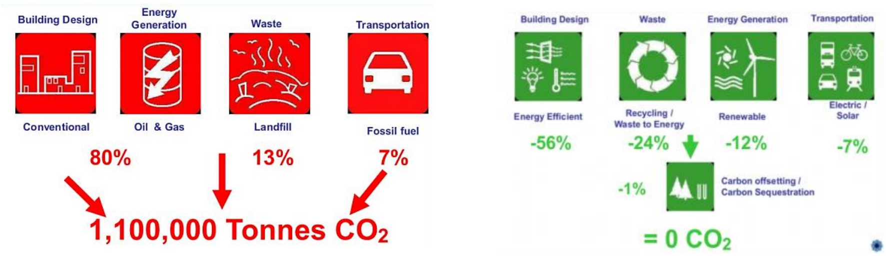


Figure (4.18): Comparison between the design of a conventional city and design of Masdar City
Source: (Masdar–Abu Dhabi future company, 2010)

1. Land-Use System: Masdar City can be represented one of the best examples that show how the mixed land uses and the attractiveness of the urban spaces are crucial to

energy conservations. The project integrated all the aspects of city life, such as work, entertainment, recreation and home, as shown in figure (4.19). It is obvious that, the vision of the city is to formulate all the characteristic features that are related to the principles of the mixed uses elements within a close proximity, thus in order to achieve the convenience and to minimize the usage of transportation. The city is committed to offering the highest quality of work and living experience with the lowest possible environmental footprint (Masdar City, 2011).

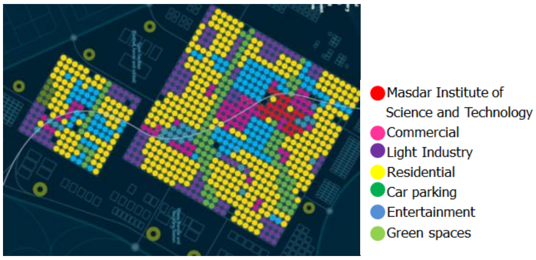


Figure (4.19): Shows the variety of functions within the Masdar City
Source: (Masdar City, 2011)

2. <u>Waste Management:</u> Masdar City can apply the concept of zero waste, through the use of waste reduction measures, reuse, recycling, composting and converting waste to energy technology, as shown in figure (4.20). All the organic waste will be converted into energy through disasters or reused as fertilizer for landscaping in which nutrient rich soil can be created (A Mubadala Company, 2010). In general, the waste to energy strategy involves the implementation of on-site recycling facilities for municipal solid waste and the conversion of organic waste materials into gas, which then runs an engine which generates electricity, as shown in figure (4.21). This supports the principal of zero waste by cutting the amounts of waste going into landfill to minimum and generating electricity from the diverted waste (Smith et, al., 2009).

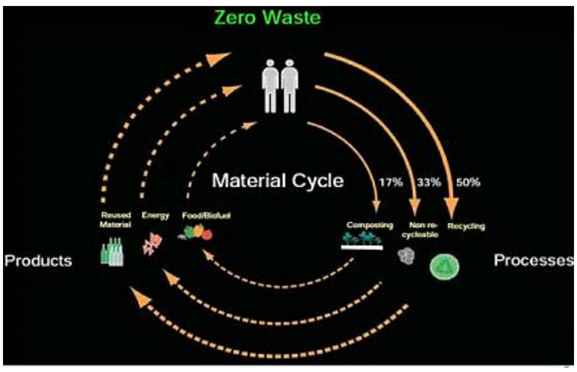


Figure (4.20): The concept of zero waste within Masdar City
Source: (A Mubadala Company, 2010)

Figure (4.21): Shows the waste collection network
Source: (A Mubadala Company, 2010)

3. Mobility System: Masdar will be one of the world's first zero car cities, as the private vehicles will not be allowed in the city (Masdar City, 2011). The main objective of the design is to reduce reliance on private vehicles and achieve major reductions of CO^2 emissions from transport. Thus, the project implements some of measures in order to achieve a sustainable mobility network, which encouraging the use of public transport, vehicle sharing, as well as support lower emissions vehicle initiatives (Stilwell & Lindabury, 2008). On the other side, due to Masdar's pedestrian- friendly design, walking and bicycling are expected to be the city's most popular forms of transit to many destinations within the city, as well as the most pleasant. For this reason the planners focus on creating shaded sidewalks and pathways (Masdar City, 2011).

In Masdar City, the mobile network is complex and consists of many tiers, as shown in figure (4.22) (Beglinger & Siegel, 2010). The first system is a light rail, which will connect Masdar to Abu Dhabi City, the adjacent international airport as well as other surrounding communities. While the second transport system developed for use in Masdar, is an underground personal rapid transit system (PRT) which relies on compact pod cars to shuttle people around the city, as shown in figure (4.23) (Tompkins, 2009). The last layer represents the pedestrian paths, which are strongly connected with the PRT stations. It's worth mention that, the PRT system represents an energy efficient way of moving people among roughly 1,500 stations, as these pod cars will run in a series of magnetic tracks using electricity (Masdar–Abu Dhabi future company, 2010). Convenience was made a priority for each of these electric transport systems, with stations available within a 200 meter radius from any location in the city (Stilwell & Lindabury, 2008).

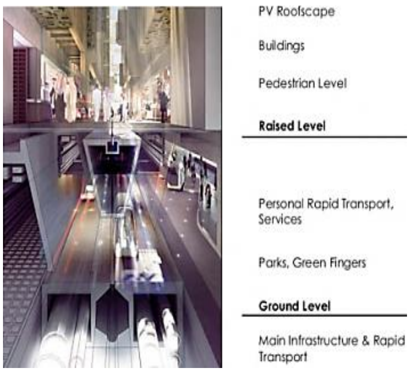


Figure (4.22): Masdar City Layering
Source: (Beglinger & Siegel, 2010)

Figure (4.23) : The personal rapid transit system
Source: (Tompkins, 2009)

Furthermore, the efficient mobile network is not only limited to the hierarchy of transportation means, but it also ensures the accessibility and connection with the services and activities. This public transportation network means that, no destination within the city will be more than 250-300m, as shown in figure (4.24) (Masdar–Abu Dhabi future company, 2010). Besides, the private vehicles will be kept at the city's edge in a number of parking lots, that will be linked by electric bus routes to other public transportation traversing the city, as shown in figure (4.25) (Tompkins, 2009). On the other side, to cater for the commuters who will travel in and out of the city every day, there is a Light Rail Transit pass through the center of Masdar City in order to connect the city with the public transportation of Abu Dhabi (Masdar City, 2011).

Figure (4.24): Masdar's Public transportation network
Source: (Masdar –Abu Dhabi future company. 20 10)

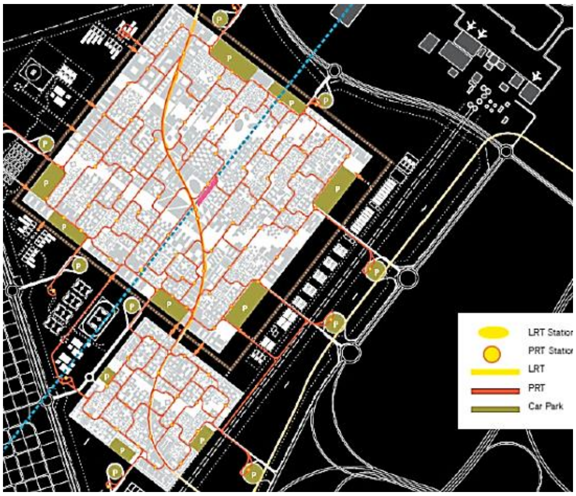


Figure (4.25): The mobility grid in Masdar City
Source: (Tompkins, 2009)

4. <u>Water Management:</u> As the city located in a harsh desert climate, a highly efficient water system is a key element of Masdar's sustainability plan. Masdar will derive all of its water from a desalinization plant located just outside the city which will run solely on solar power, as shown in figure (4.26). Masdar's planners focus to lower the city's net water demand, by achieving a 60% reduction in overall water consumption in comparison to the Abu Dhabi baseline (Masdar City, 2011). In addition to that, 80% of all water in Masdar will be re-purified and recycled back for household and irrigation purposes. As, all the landscape elements within the site will be irrigated with grey water and treated waste water produced by the city's water treatment plant, as shown in figure (4.27) (Stilwell & Lindabury, 2008).

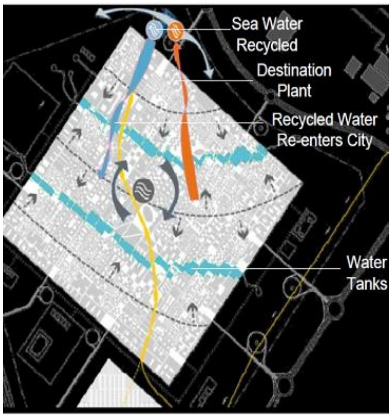


Figure (4.26): Desalinization plant location
Source: (Masdar City, 2011)

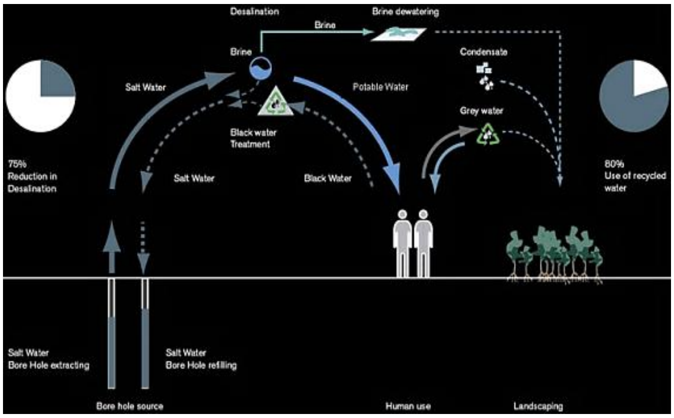


Figure (4.27) Shows the reduction in water usage
Source: (A Mubadala Company, 2010)

5. <u>Food Systems:</u> Masdar is going to be surrounded by a greenbelt featuring agricultural facilities and a variety of accessible green spaces, in which local agriculture is projected to supply a sizable quantity of Masdar's local markets. (Masdar City, 2011). Besides, vertical farming will also be used, in which the fresh food will be grown in specially designed greenhouses, as shown in figure (4.28) (Stilwell & Lindabury, 2008).

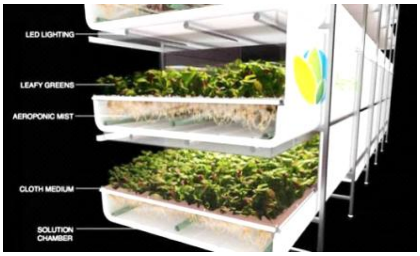


Figure (4.28): Vertical farming in Masdar City
Source: (Stilwell & Lindabury, 2008)

6. <u>Materials Conservation:</u> In Masdar the target is to specify high recycled materials content within building products and encouraging the reduction of embodied energy within materials and throughout the construction process. On the other hand, preliminary plans are being made for recycling the concrete used in city buildings when the city is ultimately torn down some time in the future. It is worthwhile to mention that, plans are being made to specify the use of sustainable materials which are 100% sustainably, such as grown timber, bamboo and other products. Also, the city is using low carbon cement and two types of aluminium with 90% recycled aluminium content used for the inner façade. In addition to that, recycled steel reinforcing bars, green concrete that used ground granulated blast slag to replace cement, as well as water based paints that have no volatile organic compound, which harm human health (Masdar City, 2011 & Stilwell and Lindabury, 2008).

7. Natural Systems: Although Masdar is being built in a desert environment where few plant or animal species live, the region's biotic communities have not been forgotten. Masdar has pledged to mitigate for any impacted plant and animal populations. Mitigation will occur on comparable habitat sites, as effective conservation is a key element of Masdar's sustainability goals (Masdar City, 2011). Masdar objective, according to the natural habitat is that, all valuable species are conserved or relocated with positive mitigation targets. In addition to that, vernacular based landscape strategy using local species for reduced irrigation demands and consolidated open spaces and recreational areas (Stilwell & Lindabury, 2008).

8. Housing: The city includes an appropriate mix of housing types, sizes and density, resulting in diverse, safe and socially active places to live. Figure (4.29) shows an example of the diversity of housing types, sizes at Masdar project 1. The project mainly consists of different type of house like the courtyard units or the town houses which consist of 2 units or even consist of 4 units. This actually refers to the diversity of the housing stock, which is critical to a socially and economically diverse society (Archi Worlds, 2014). On the other side, according to a study done by Stilwell B. & Lindabury (2008) which demonstrated that, there is a lack of planning for affordable housing to promote equity, this means that Masdar is not as sustainable as its developers suggest.

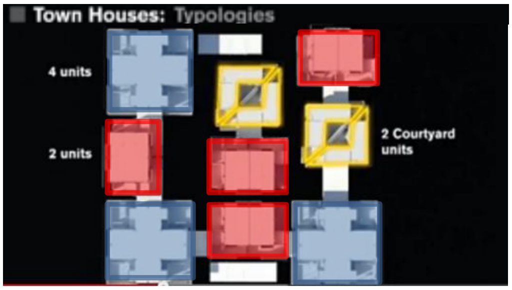


Figure (4.29): Masdar project 1 designed by Foster + Partners
Source: (Archi Worlds, 2014)

9. Energy Efficiency: The city will minimize energy demands by deploying the most energy efficient techniques and then the remains demand will be met using renewable energy to reach the 100 percent of the energy needs (Stilwell & Lindabury, 2008). In a comparison to today's UAE standards, a reduction of 80% needs to be achieved. This reduction can be achieved by the three following steps in order to reach a sustainable development with a carbon neutral operation (Beglinger & Siegel, 2010).

9.1. <u>Energy Consumption:</u> The first step is a load reduction through passive design strategies which will reduce primary energy consumption by 40% compared to today Abu Dhabi references. So the planners recognized that, the biggest environmental gains come from some of the most passive and least expensive tools (Beglinger & Siegel, 2010).

9.1.1. <u>Urban Scale:</u> Masdar capitalizes on a number of clever urban design elements to reduce net energy demand in this hot and humid climate, as it is one of the most important measures for the sustainable approach in the city (Masdar City, 2011).

I. <u>Orientation:</u> Masdar has been oriented northeast to south-west to provide an optimum balance of sun and shade. By optimally orienting the city grid and buildings, solar heat gain on building walls and the street will be minimized, while cooling night-time breezes will be maximized (Stilwell B. & Lindabury S., 2008).

II. <u>Wind Direction and Velocity:</u> In the Masdar development, streets are mainly used for fresh air distribution and micro climate protection. On the other side, two green park bands through the whole city are oriented towards the sea breeze and the cool night winds. They create the necessary fresh air corridors through the large city grid. They also make best use of the cooling night breezes and lessens the effect of hot daytime winds, as shown in figure (4.30) (Stilwell B. & Lindabury S., 2008). In addition to that, the entire city will also be suspended on stilts rising six meters from the ground, so as to increase air circulation and to keep the city off the hot desert floor. It is also worth mentioning that, buildings' massing have been designed to make the most of the fresh prevailing wind across the site. Some buildings used the internal courtyards, while the other used the stepping of the building's mass from the higher northern corner towards the south helps, in order to increase the penetration of the air fresh, as shown in figure (4.31) (Aedas, 2013).

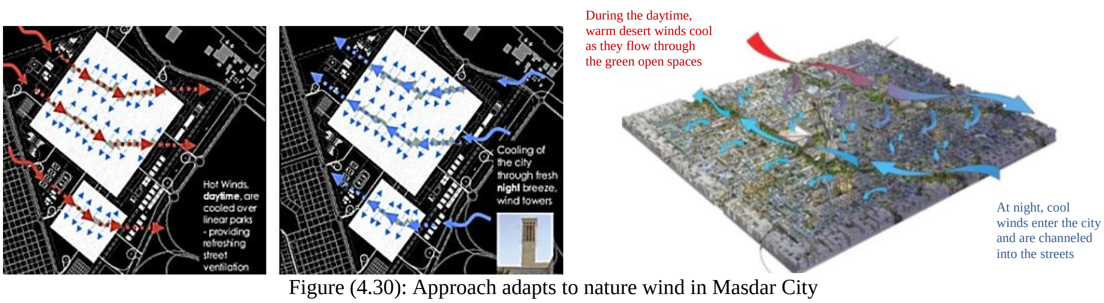


Figure (4.30): Approach adapts to nature wind in Masdar City
Source: (Beglinger & Siegel, 2010)

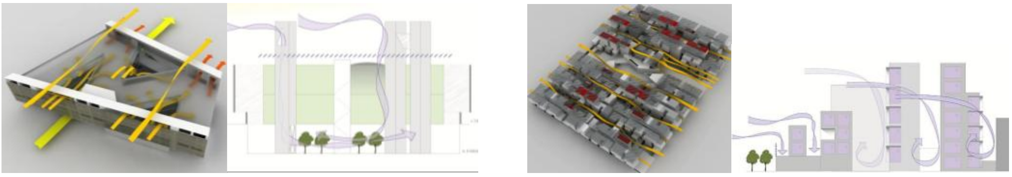


Figure (4.31): Wind penetration through the internal courtyards and the stepping of buildings' mass
Source: (Aedas, 2013)

III. <u>The Exterior Environment:</u> In Masdar, the target is to specify high recycled materials within the surrounding environment. Besides, encouraging the reduction of embodied energy within materials used in the landscape elements (Stilwell & Lindabury, 2008). All the walkways on the site will be finished by high recycled content such as recycled glass or porcelain tiles (Palmer, 2009). Figure (4.32-4.33) shows that, the specifications of the materials used for the exterior surfaces were properly selected. As those exterior urban surface are mainly depends on using high-albedo materials, which will impact directly on energy consumption within the district (Masdar City, 2011).

Figure (4.32): Carefully planned the exterior environment
Source: (Masdar City, 2011)

Figure (4.33): Material of the exterior environment
Source: (Masdar City, 2011)

IX. <u>Solar Radiation:</u> As the city located in a harsh desert climate, comfortable indoor and outdoor spaces have to be carefully sun protected, but not totally darkened. In the first step the solar exposure and illumination of street locations for different street width were analyzed with the help of sun path diagrams and shading analysis, as shown in figure (4.34) (Tompkins, 2009). Then, the design guideline for the sizing of facade openings has adjusted respecting the high level of direct radiation on the project site. Also take in consideration that, all the building should provide self-shading (Masdar City, 2011).

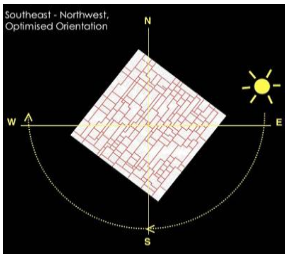


Figure (4.34) Masdar's design approach adapted to the sunpath
Source: (Tompkins, 2009)

X. Block Density: The city will feature density, low rise buildings with no more than five storeys, that in order to create a compact community with narrow streets. These narrow streets will help to keep out the desert sun and allow gentle breezes to flow through. The compact area will draw inspiration from traditional Arabic cities, where the narrow streets and natural shading, in order to reduce outdoor temperatures and make it possible to comfortably enjoy the outdoors longer than is currently possible in Abu Dhabi's summer heat and humidity (Tompkins, 2009 & Masdar City, 2011)

XI. Landscape: Carefully planned landscape will aid in reducing ambient temperatures, while enhancing the quality of the streets. The figure (4.35) shows an example of using the private gardens between the buildings. In addition to, the green parks which separate the built-up areas, capturing and directing cool breezes, while providing cool oases throughout the city (Palmer, 2009). Furthermore, all the city's landscape elements include local plants which do not need a lot of water. All these elements will be irrigated with treated wastewater, allowing Masdar's total water demand to be less than half that of a regular community (Masdar City, 2011).

Figure (4.35): Shows example of the private gardens between the units in Masdar City
Source: (Archi Worlds, 2014)

XII. Water Features: The project also depends on using water features between the building in order to increase the cooling potential of a natural ventilation design strategy, as well as help in decreasing the outdoor temperature. The figure (4.36) shows an example of using the water features between the buildings (Palmer, 2009).

Figure (4.36): Shows example of the connecting water features between the units in Masdar City
Source: (Archi Worlds, 2014)

XIII. Exterior Block Properties: The design of the project depends on using buildings and with high-albedo materials, which will directly affect the indoor and outdoor thermal comfort and consequently reduce the energy demand for cooling in the summer. From another side, the buildings' mass help in minimizing the adverse wind effects and optimize conditions for passive ventilation and cooling, which directly minimize overall energy consumption requirements (Masdar City, 2011).

9.1.2. Architectural Scale: Next the most effective step is optimizing the building performance through using efficient buildings envelope and systems. It is worth mentioning that, the design concepts for the residential façades differ from the other building within the campus, in which they are designed by the best available international energy efficient techniques, in order to minimize energy consumption. They are design by setting stringent building efficiency guidelines in areas such as insulation, low energy lighting specifications, the percentage of glazing and optimizing natural light (Beglinger & Siegel, 2010).

I. Walls: The main concept for the residential façades was to have a self-shading façade, which designed to respond to their orientation, as well as shading the adjacent buildings and the street below. The façades were designed as multiple layers, comprising an external balcony with screen layer, inner façade and insulation layer. Each layer provides a functional response to dealing with the harsh desert environment (Palmer, 2009). It is worth mentioning that, to satisfy Middle Eastern norms for personal privacy, the residential buildings of the campus are enclosed in a wavy facade of concrete latticework, similar to the traditional screens known as mashrabiya, as shown in figure (4.37). The latticework shields and the balcony spaces are form the first layer and were designed to provide excellent shading of the main residential envelope façade. Their curved forms provide direct oblique views down narrow streets, while maintaining privacy (Masdar City, 2011).

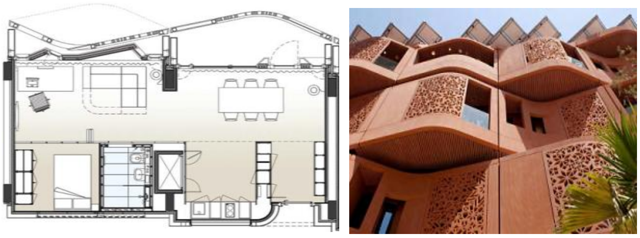


Figure (4.37): Masdar's residential modular unit with the curved form
Source :(Palmer, 2009)

On the other hand, the lightweight façades also serve to minimize and limit the embodied energy in their fabrication and construction. In general, the majority of building materials used in Masdar has a high thermal mass, resulting in high levels of insulation in the city's buildings. As, the selected GRC fabrication panel has helped in meeting this challenge with its inherent properties and its manufacture, in addition to its thickness, which range from 25 to 30mm thick (Palmer, 2009).

II. Openings: The second inner layer was a combination of solid aluminium glazing panels and timber framed windows. The extent of solid and glazed elements was developed with an average glass to solid ratio of 35% to minimize heat gain (Tompkins, 2009). The ratio of the openings of the façade varies according to their position, the upper floors are more exposed, so approximately 25% is glass. While the shaded lower floors have a greater percentage of glazed area, around 45%. This inner layer of 90% recycled aluminium reflects light within the balcony and its thermal qualities of high thermal conductivity allowing it to cool down quickly (Palmer, 2009).

III. Insulation: The third and final layer was the insulation layer within the well-sealed inner façade. This approach concentrated on conserving the energy used to cool the apartments, thus by minimizing the extent of the conditioned air being lost through the façade, as well as additional heat being radiated in. In general, this insulation layer ensured that any heat gain of the external elements would not be radiated within the apartment and also prevent infiltration occurred (Palmer, 2009).

IV. Roof & Ceiling: The shape of the roof encourages the air flow, as shown in figure (4.38). On the other hand, the design depends on using circular openings in the roof of the balconies, so that the apartments can be naturally ventilated during the winter days and often typically in the evenings (Palmer, 2009).

Figure (4.38): Example of the roof shape which encourages the air flow in Masdar City
Source:(Archi Worlds, 2014)

V. <u>Daylighting Techniques:</u> The design depended on using the high level clerestory and vertical slot windows in the walls, which maximize daylight and reflect light into the apartments. Besides, there are some buildings using the courtyards to increase the penetration of the daylighting, as shown in figure (4.39) (Palmer, 2009).

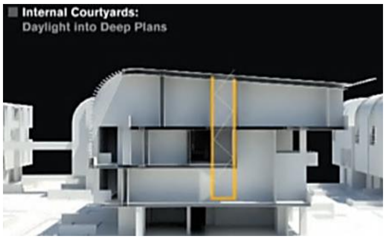


Figure (4.39): Example of the internal courtyard which enhances the daylighting into deep plans in Masdar City
Source: (Archi Worlds, 2014)

VI. <u>Natural Ventilation System:</u> As explained above, the majority of the buildings designed around the courtyards, which supporting the building's natural ventilation strategy. This typology has become a typical in the hot arid climate. As, they can act as a means of supporting the building's natural ventilation strategy by acting as a source of cooler fresh air during the winter (Palmer, 2009). On the other hand, each apartment should maximize the cross ventilation within the unit, even if it does not depend on a court, they can use a solar chimney or any other techniques to enhance the natural ventilation within the building, as shown in figure (4.40) (Aedas, 2013).

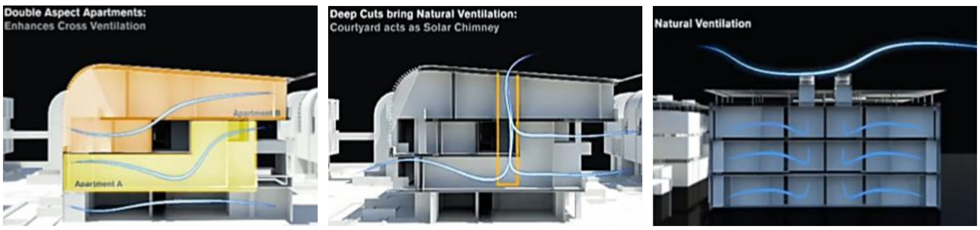


Figure (4.40): Different techniques in Masdar City to enhance natural ventilation into deep plans
Source: (Archi Worlds, 2014)

VII. <u>Shading Devices:</u> The main concept for the residential façades was to have a self-shading façade, which designed to respond to their orientation, as well as shading the adjacent buildings and the street below. So the majority of buildings should be provided by self-shading systems, as shown in figure (4.41) (Aedas, 2013). Besides, the using of the balcony spaces and vertical mashrabiya screens with its curved forms, in order to provide excellent shading (Palmer, 2009).

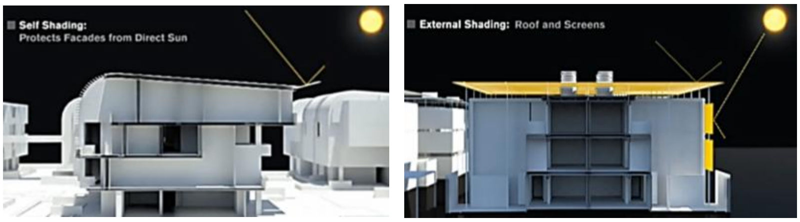


Figure (4.41): Self-shading system façade used in Masdar City
Source: (Archi Worlds, 2014)

9.2. <u>Energy Distribution:</u> The second step is to optimize the building performance through using smart building management system, which will allow a further saving of 30% to 40% (Beglinger & Siegel, 2010). As part of the agreement, Siemens will provide smart utility grids which enable the using of renewable decentralized energy generation, also provides the smart home, which enable the using of integrated building automation technologies such as smart appliances. This consequently helps in optimizing energy consumption in the City. All of these facilities will collect user data and consumer reaction to shape product design and automation while supporting Masdar City to achieve their energy efficiency targets. On the other hand, the energy solution will function by integrating several building management systems and vertically linking them to an advanced energy distribution management system. By connecting the district with this system, the ability to implement end-to-end demand response from the utility direct to consumers will be created (Masdar City, 2011).

9.3. <u>Energy Generation</u>: Finally, renewable energy sources and actively renewable strategies will reduce the primary energy demand of the remaining 20 - 30%.Those resources are the most expensive, while offering the lowest relative environment impact returns. That’s why designers first concentrated on orientation and performance optimization, thereby reducing a large amount of energy demand with little cost and only subsequently looked at what active controls could be implemented (Beglinger & Siegel, 2010). Masdar City aims to maximize use of renewable energy, which is one of the largest sources of carbon savings. This aim is mainly to show that, the UAE is doing something to lower its carbon footprint internationally, as well as to stay in the energy business in the future by diversifying into alternative energies (Masdar –Abu Dhabi future company, 2010 & Stilwell and Lindabury, 2008). In general, Masdar is relying solely on renewable energy to supply 100% of its electricity. The city will use the most advanced renewable energy technologies, 80% of this ratio is solar energy and the rest is gained from wind energy installations and the conversion of waste materials, as shown in figure (4.42) (Beglinger & Siegel, 2010).

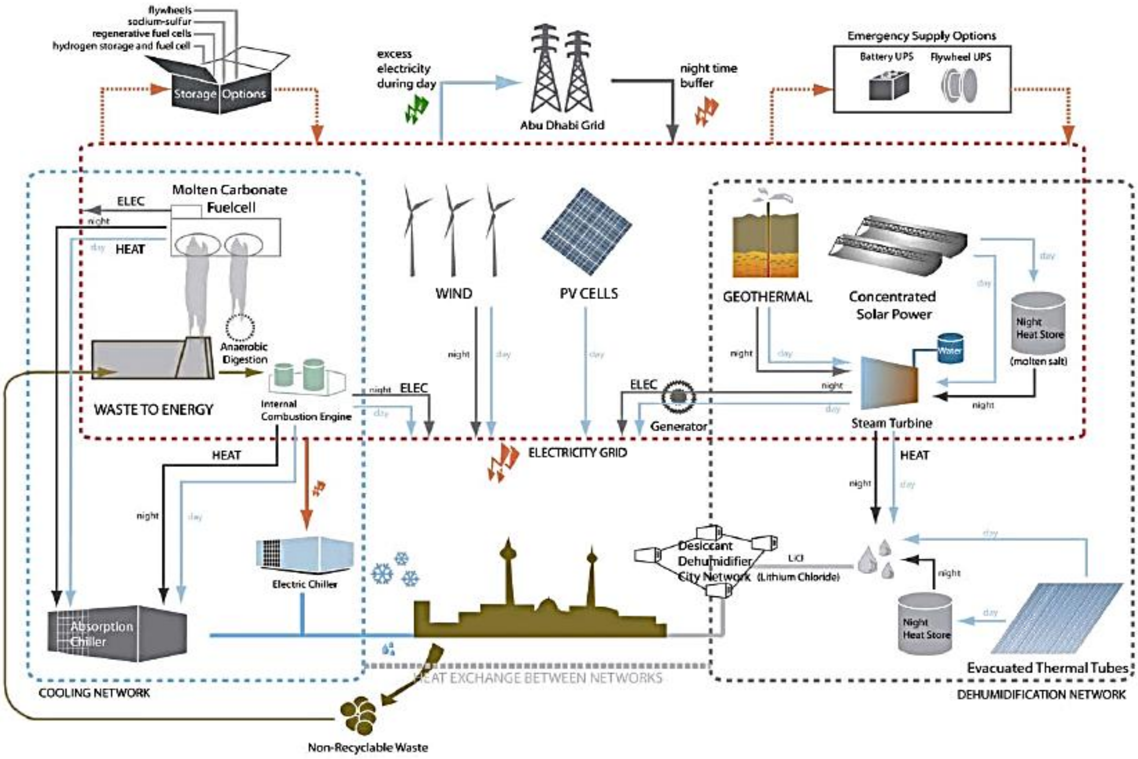


Figure (4.42): The strategy of 100 renewable energy in Masdar City
Source: (Beglinger & Siegel, 2010).

- **<u>Off-site Renewables:</u>** There are direct investments in individual projects in all areas of renewable energy, with a focus on a diverse mix of solar and wind projects. Those projects include photovoltaic and wind technology, which installed in both onshore and offshore locations. They are being implemented on both large and small scale and in both major metropolitan areas such as London Array and smaller settings such as the Seychelles. This mix of international and UAE projects and varied technologies offers many opportunities for knowledge sharing. It is worthwhile to consider that, Masdar Power can more effectively achieve its strategic objects and contribute to Abu Dhabi's goal through these future projects (Sorensen, 2010 & Stilwell & Lindabury, 2008).

- **<u>On-site Renewables:</u>** In addition to the several projects located around the city, there will also be other integrated renewables into the majority of the city's architecture and outdoor spaces, as shown in figure (4.43) (Stilwell & Lindabury, 2008).

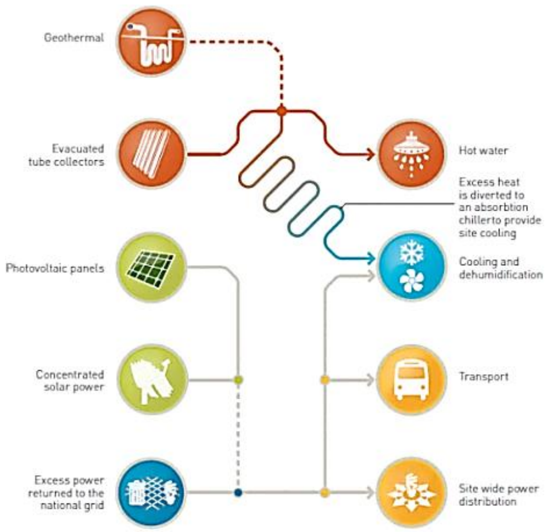


Figure (4.43): Diagram shows the energy production methods within Masdar City
Source: (Masdar City, 2011).

1. <u>Photovoltaic Panels:</u> In addition to several photovoltaic power plants located around the city, solar panels will also be integrated into the majority of the city's architecture and outdoor spaces. Some of these panels will be mounted on the rooftops of the majority of the buildings, as shown in figure (4.44). While additional thinner film photovoltaic canopies will be incorporated over the streets, in order to provide an additional source of energy while shading for the pedestrians. Besides, the city center will be covered with shades, that open during the day to absorb energy and close during the night and provide energy for lighting, as shown in figure (4.46) (Masdar City, 2011). It is quite important to mention that, these photovoltaic panels will comprise the majority of the city's on-site renewable energy generation, as it will generate power for the city, while cooling will be provided with concentrated solar power (Masdar –Abu Dhabi future company, 2010).

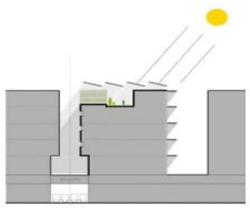


Figure (4.44): Shows roof mounted panels center Source: (Masdar City, 2011)

Figure (4.45): The photovoltaic shades which covering the city
Source: (Masdar City, 2011)

2. <u>Wind Turbine:</u> Wind turbines are also anticipated to be a central part of Masdar's energy mix. The city's southwest and northeast walls will be lined with large wind turbines and smaller urban wind turbines will be affixed to various buildings throughout the city (Stilwell & Lindabury, 2008). In addition to the existence of the wind tower, which is one of the region's most iconic traditional architectural features. It rises 45m above the street, which help in capturing the upper-level winds and direct them to the open-air public square at its base, as shown in figure (4.46) (Palmer, 2009).

Figure (4.46): Shows the wind tower in Masdar City
Source: (Palmer, 2009)

3. <u>Solar hot water:</u> Besides conventional photovoltaic, Masdar is also planning to generate cheap concentrated solar thermal power which uses mirrors to focus sunlight and create steam (Palmer, 2009). Concentrated solar power technology is being tested as a source of thermal energy for single and double effect absorption chiller systems, which could meet a significant portion of the city's cooling demand. Evacuated tube collectors will be roof mounted to provide domestic hot water and a base load that can be used for dehumidification (Masdar City, 2011).

4. <u>Geothermal:</u> In addition to that, geothermal ground sourced heat pumps are also being planned to play a major role in cooling Masdar's buildings from the harsh desert climate. The feasibility of using deep geothermal hot water as a thermal energy source currently is being evaluated (Masdar City, 2011).

- **<u>Observation on Masdar City:</u>**

Although Masdar City is a great investment in alternative energy sources, also it can serve as testing grounds for experimental technologies, several questions have been raised about the success of the city, such as the advantages and the disadvantages of its planning and the overall ability of the city to succeed. Here is a brief of some of the criticism points:

- Pros: It's worth mentioning that, it stands as a testament project to show the entire world how the future without oil could be look like and how renewable, clean energy can power an entire metropolis (Masdar City, 2011). Also, it can show how to incorporate the advanced energy and water saving techniques, which modelling the sustainability practices of the future (Stilwell & Lindabury, 2008).

- Cons: It's worth mentioning that, the international energy experts said that, the whole project is just a big show. This may be returned to the presence of a lot of negative points concerning that project (Deutsche Welle, 2013). Among those points are:

1- Some energy experts demonstrated that, there are numerous planning flaws within planning the city. This mainly returns to the reason that, some of its technologies have not proven capable of overcoming the harsh desert conditions, which make the project fully viable. For example, the photovoltaic panels have only been tested in optimum conditions, not in the actual desert setting. Meanwhile, those panels outside the city are proving less efficient than expected because of the dust storms and haze, which can cut the solar insulations by about 30%. Another concern, that some solar panels on the roof of the showcase buildings were actually in the shade which means that, they also produce significantly less energy (Deutsche Welle, 2013).

2- Another concern is that the funding for the project comes from unsustainable means. It's worth mention that, the fund used for building Masdar is funded almost through the revenues from oils and gas exports (Deutsche Welle, 2013).

3- There is also another criticism about the project: as it represents inherently unsustainable because it involves constructing a brand new city in an unsuitable place, which is the desert. The project, even though it will be carbon neutral, the construction process itself can be unsustainable, due to the large amounts of carbon released and the large quantities of energy, land and water, which are consumed in order to construct and sustain (Ekblaw et al., 2009).

4- On the other hand, despite Masdar City is a step in the direction of environmental sustainability, the cost of the city is so large. As most of the energy experts believe that, there are many simple and more effective solutions can be used, such as better insulation for the buildings. It's worth mentioning that, those solutions would have been better for the environment and more cost effective. Besides, there is agreement that the CO^2 neutral energy supply with renewables would not require such a gigantic project and it would be a much better idea if they spent the money on other many projects (Deutsche Welle, 2013). Thus, this means that the project is not the best use of the funds. From another perspective, not every nation in the world has this fund to make such ambitious urban planning projects, which depend mainly on renewable technologies (Ekblaw et al., 2009).

5- Another concern about Masdar that, although it represents an eco-city, it does not contribute to increasing the sustainability of the United Arab Emirates as a whole. As, the UAE represents one of the most unsustainable and largest carbon-emitting areas in the world (Ekblaw et al., 2009). Critics see the project first and foremost as a clever project, which concerned only to improve Abu Dhabi's image than focusing on the environmental sustainability. This may be returned to the fact that, the environmental impacts of the project are highly dependent only on where its boundaries lie. Thus, Masdar's claims of producing zero carbon emissions even within the city itself are misleading (Deutsche Welle, 2013).

- <u>The overall ability of the city to succeed:</u> Although critics have pointed out several major flaws with the sustainability of the city and its usefulness as a model for other cities, no one can deny that Masdar is a visionary project that will help develop green technologies. As no project is totally perfect, thus it is in overall represents a step in the right direction (Stilwell & Lindabury, 2008). Even if the city as a whole is not useful for existing cities to be model, the model parts of the Masdar's technologies can be used throughout the world, such as the PRT system or the development of the solar and zero waste technologies (Deutsche Welle, 2013). Hopefully, Masdar will overcome its shortcomings and use the linkages between all sectors of the city, thus it can really serve as an active laboratory that inspires the UAE and other region. As well as, it can make a real contribution towards developing renewable energy technologies. While, if it stands alone as an isolated green jewel and the rest of the UAE proceeds with the current path, then it can be only called as a green washing project (Ekblaw et al., 2009).

4.6. Wilhelmsburg (Hamburg, Germany):

Hamburg's Wilhelmsburg district was taken as an example to examine the developments for future energy requirements. For decades, the district of Wilhelmsburg, faced multiple threats, which includes the natural hazards, such as possible flood disasters. In addition to, the ecological threats such as the toxic emissions from local industries. In order to take an action according to those threats, the city of Hamburg established the International Building Exhibition (IBA), which is a temporary urban development initiatives. The IBA Hamburg started from September 2006 to November 2013, along that period over than 60 projects were carried out in the Elbe islands of Wilhelmsburg, Veddel together with Harburg Upriver Port. The IBA Hamburg's main aim of this project, especially the climate protection concept renewable Wilhelmsburg, was to demonstrate solutions for the urban largely built-up environment in contrast to Masdar. Where in Masdar, the goal was how to build a brand new sustainable city from scratch, while in Wilhelmsburg the goal was how to transform a fossil fuel nuclear city into a solar sustainable city, that is ultimately able to source 100% of its supply from renewable energy (IBA Hamburg, 2010).

- Background & Overview:

Wilhelmsburg is a quarter of Hamburg with a population over than 50,000. It's the largest river island in Europe and the biggest district in the term of area in Hamburg. It is located next to the harbor and docklands on an island between the Northern and Southern branches of the Elbe River, as shown in figure (4.47). After the great storm in 1962, the lives of hundreds of people from the Elbe islands were claimed, so that many residents left the devastated islands. In subsequent years, those islands became problem areas and a source of negative headlines. For this reason, the International Building Exhibition (IBA) Hamburg was addressing the issue of how a city should prepare itself for the future, by finding solutions to the pressing issues which facing the modern cities (IBA Hamburg, 2010). Figure (4.48) shows the IBA Hamburg project area.

Figure (4.47): Wilhelmsburg Island
Source: (IBA Hamburg, 2010)

Figure (4.48): The IBA Hamburg project area
Source: (IBA Hamburg, 2010)

- Wilhelmsburg Vision:

The IBA Hamburg's key theme was a reaction to the current challenges which facing the cities, such as the climate changes and the growing scarcity of fossil fuel resources. Thus, the main vision was to present an overall model of how a whole district can become independent in terms of energy as well as improve the population's quality of life. This example presented practical evidence of the potential for saving energy, increasing efficiency, as well as strategic steps for optimizing energy supply by using renewable energies. In general, the analytical methods used here form the basis for urban action strategies, demonstrating how cities in particular can become the pioneers of climate protection and resource conservation (IBA Hamburg, 2010).

- Wilhelmsburg Vision towards Sustainable Development:

The IBA's many future oriented ideas and projects are already of tremendous benefits for the whole Hamburg. Furthermore, they provide a strong impetus for international discussion on sustainable development. With the IBA, Hamburg has a special opportunity to be able to develop concepts for a sustainable city and thus to exert a positive influence on the development of cities throughout the world. On the other side, the IBA Hamburg has been concentrating on the vital questions concerning metropolitan development, such as the living together of different cultures or reasonable and healthy ways for a city to grow. It's quite important to mention that, they were working under real conditions, this means that the IBA dealing with the real economic, social and demographic solutions and taking them into consideration as key parameters and variables for the implementation of strategic climate protection concepts (IBA Hamburg, 2010).

On the other side, it's worthwhile to mention that, all the IBA's construction projects were trying to apply the requirements which exceed the requirements of the law of "German Energy Saving Regulation (ENEV2009)" by 30%. In fact, these projects targeted to implement the strategies of the "Passive House Plus and the "Zero energy House". In addition to that, there are some projects are also intended to be certified according to the guideline of the "German sustainable Building Council (DGNB)" and achieved its Gold Standard. (IBA Hamburg, 2010).

- Environmental Aspect:

It's worthwhile to mention that, the IBA has given the urban development new social, technical and cultural impetus. The projects which have been carried out by the IBA Hamburg, creating an impetus for sustainable, environmentally friendly and socially balanced urban development. Below, there is a brief description of how major cities can grow in an environmentally friendly way by generating decentralized renewable energy and using their own resources efficiently (IBA Hamburg, 2010).

1. Land-Use System: The example is based on the ideal form of the high density and mixed-use cities. It's worthwhile to consider that, the IBA's project applied different concepts in order to achieve diversity within the area. This diversity of utilization improves the social control in the neighborhoods, improve the local supplies, increase the local job opportunities, as well as help in reducing traffic. Thus, IBA developed some appropriate strategy of actions in order to promote such mixed utilization. Among those actions are: enriching residential areas with other utilization, incorporating residential usage into commercial areas, as well as temporary use of vacant properties (IBA Hamburg, 2010). Figure (4.49) shows the IBA spatial actions in order to promote mixed utilization. In general, IBA main target by 2013 that, a lot of projects were being built, in order to achieve the mixed utilization within the area. Among those projects, there are a total of 1,733 residential units, in addition to 100,000 m^2 of commercial space, eight educational establishments, two senior citizens' homes, three day nurseries, four sports facilities, a commercial park, a center for artists and creative workers, as well as over 70 hectares of green space (Mebus, 2011).

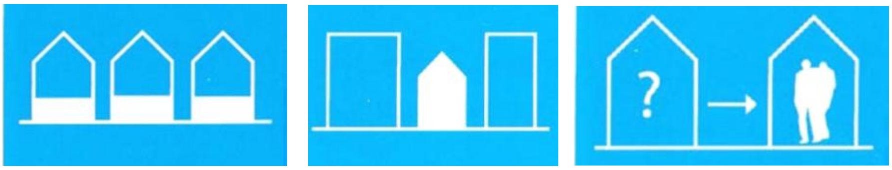


Figure (4.49): IBA spatial actions in order to promote mixed utilization
Source: (IBA Hamburg, 2010)

2. Waste Management:: It is obvious that, waste can be a resource for the use of urban Bioenergy, in which the waste problem transformed into a clever supply solution. Thus, materials which were generally disposed of, such as the woods and the grass cuttings, are collected in the same areas and then turned into biogas in dry fermentation plants and in order to produce electricity and heat in CHP plants (IBA Hamburg, 2010).

It's worth mentioning that, setting up collection logistics for residual materials from landscape maintenance and using the energy from the Elbe Island’s biomass will reduce unnecessary transportation and bring unused resources into use. Figure (4.50) shows the IBA urban Bioenergy project (Mebus, 2011).

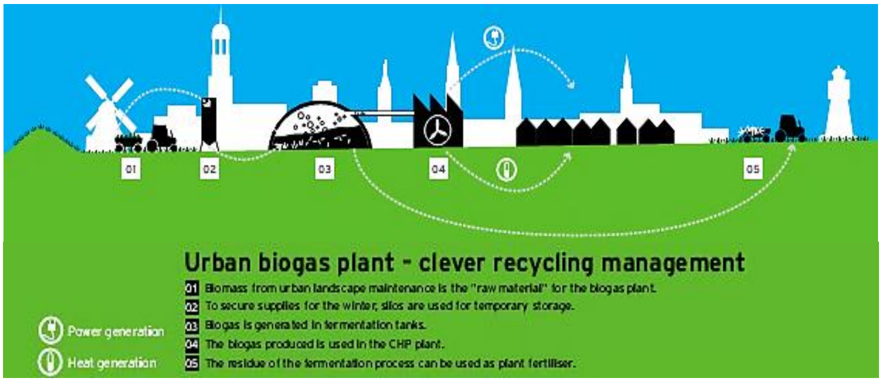


Figure (4.50): Shows the IBA Urban Bioenergy project
Source: (IBAHamburg, 2010)

3. Mobility System: At present, about 25% of Hamburg’s carbon emissions are caused by transport, mostly passenger cars and smaller commercial vehicles. Hamburg aimed to increase the share of environmentally acceptable transport, in order to avoid the continuous growth of carbon emissions in parallel with transport, so that it could meet the need to combat climate change. It is improving its public transport system, improving cycling infrastructure, promoting the car-sharing schemes, as well as improving the pedestrian infrastructure and make it more attractive in order encourage walking. In addition to that, regulations for the purchase of low-emission cars for public authority vehicle fleets are in preparation. Besides, environment friendly technologies in Hamburg transportation are promoting, such as the electric vehicles, environment friendly taxis and power optimized transport infrastructure, such as LED traffic lights (IBA Hamburg, 2010). On the other side, it also aimed to achieve a great maintenance of power supply from renewable energy sources for U-Bahn and S-Bahn, as well as providing 100 public charging stations for the electric vehicles. The last concern is that, one-third of the world’s container shipping fleet is in German ownership, thus development of the bonus for environment friendly ships could also make a significant contribution to climate change mitigation (Mebus, 2011).

4. Water Management: Some of IBA’s projects mainly succeed in using the water cycle drainage concept. One of the good examples is the ‘Reference Project New Living in Jenfeld’, with this district the city owned Infrastructure Company, which aimed to

implement as part of the large scale project, which is the Hamburg water cycle darning concept. In this project, all the rainwater, the black water, as well as the grey water or any other waste water is to be collected, treated and subsequently reused. Also, in this project all the households will be equipped with vacuum system so it can be fed into treatment plant where it can be left to ferment into biogas along with other biomass (IBA Hamburg, 2010). It is also worthwhile to consider that, there are practical projects have shown that all the domestic waste water can be used to meet the generation of electricity and heat requirement within the buildings (Mebus, 2011).

5. Food Systems: In an act of self-sufficiency, the city encourages the sustainable food production and supply, in order to reach a concrete step towards sustainability (IBA Hamburg, 2010).

6. Materials Conservation: The IBA action plan concentrated on their strategy on saving the resources and making efficient use of materials, in order to create sustainable cycles (Mebus, 2011). On the other side, the main objective of the IBA is to provide solutions for housing construction in the twenty century. Thus, the using of intelligent building materials of the future is the focus of the IBA's Hamburg projects, such as the "smart material hoses' which represents new generation of house type characteristic of the intelligent development of usage and combination of flexible building construction materials and technologies (IBA Hamburg, 2008). It's worth mention that, the application of such a smart material and smart technologies promotes the optimization of material properties and energy channels, which in turn have a positive effect on ecological and sustainable building work (IBA Hamburg, 2010).

7. Natural Systems: It's worthwhile to mention that, there are many practical projects of the IBA's projects provided the best possible habitat for biodiversity in the urban environment, such as promoted the idea of using green roofs and local frames, as well as provided over 70 hectares of green space. In addition to, the 'Art project: sculpture, beds in the intercultural garden'. Actually, this International Garden is an artistic and social project providing a creative response to industrial and social contamination by making garden bed sculptures and working on intercultural gardening. Besides, they also consider the idea that, harbor and nature do not have to be dramatically opposed, so that an integrated network of many small harbors biotopes, flexible both temporally and spatially, would offer the best prospect for a green harbor (IBA Hamburg, 2008 & IBA Hamburg, 2010).

8. Housing: The city includes an appropriate mix of housing types, sizes and density, such as multi-storey housing, town housing and single family homes. All of these types resulting in diverse, active places to live. As well as, there are a lot of practical examples of the IBA's projects designed to provide high quality and attractive rented or individually owned dwelling for low and middle income classes, such as the project of the 'smart price house'. The other designed for social and affordable housing such as 'Reference Project New Living in Jenfeld'. All of theses projects are mainly applied to the high energy efficiency and sustainability standards in general with high quality value (IBA Hamburg, 2010). This actually refers to the affordability and diversity of the housing stock, which is critical to a socially and economically diverse society.

9. Energy Efficiency: Like other cities, Hamburg is faced with the challenge of making its energy supply sustainable and climate friendly, in order to achieve the ambitious goals of greenhouse gas reduction and at the same time ensure supply security. These ambitious goals for CO2 reduction can only be achieved if Hamburg uses a large proportion of carbon-free energy for power and heating, which depend on renewables (IBA Hamburg, 2008). It's worthwhile to mention that, Hamburg provided funding for renewables such as biomass, thermal solar heating, wind power and geothermal energy. That also included the inclusion of renewable in energy efficiency modernization of existing buildings (IBA Hamburg, 2010).

It's worthwhile to mention that, there are four periods were determined up until the forecast horizon of 2050. A concrete examination of two different scenarios illustrating development in 2013/2020/2050, which applying the Germany wide trends in renovation, efficiency and the introduction of renewable energy to the Elbe Islands. The both scenarios presume a change in the distribution of urban environment and landscape types. Use was made of the two reference scenarios, in order to demonstrate the possible impact of a district heating network on the Elbe Islands, supplied by the Mooburg coal power station currently under construction. Other, two so called excellence scenarios were developed as an alternative to the reference scenarios to incorporate concrete IBA projects and also examine different areas of emphasis in renewable energy supplies. The two scenarios share the fact that they are local and decentralized solutions adapted to the special local ability to achieve autonomy in renewable energy (IBA Hamburg, 2010).

In general, the pilot concept is the transformation of the fossil fuel or nuclear city into a solar, sustainable city, that is ultimately able to source 100 per cent of its supply of renewable energy. This transformation is taking place at a sociocultural, economic and ecological level, in which entirely new strategies are required. The intention is not the development of the theories, but a demonstration of the practical solutions in this showcase area to show how it could be. Figure (4.51) shows the Future Concept Renewable Wilhelmsburg (IBA Hamburg, 2010).

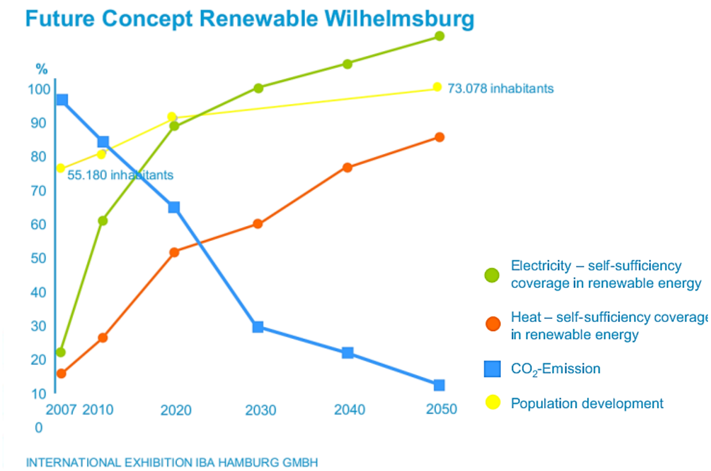


Figure (4.51): Future Concept Renewable Wilhelmsburg
Source: (IBA Hamburg, 2010)

On the other hand, in addition to the many ambitious energy projects, the IBA Hamburg increasingly worked towards not merely having this project stand in isolation, but utilizing the special features of this urban island and to attempt the perpetration of an overall concept, which is a kind of road map, showing the way into the post fossil fuel and nuclear free age. According to this IBA created their spatial energy concept and a plan of action that can serve as a prototype for renewable Hamburg, as shown in figure (4.52). It's worth mentioning that, the IBA Hamburg intends to set new standards for resource conservation and climate neutral construction with this spatial energy concept, optimized building services engineering and the ambitious renovation of existing buildings reduce energy consumption, while co-generation units and regional and local energy supplies in order to improve the energy efficiency. That led to a significant change to the form of city, performance, landscape, as well as its architecture (IBA Hamburg, 2010). The following part attempts to draw up some guidelines for this transformation based on the IBA's spatial energy concept.

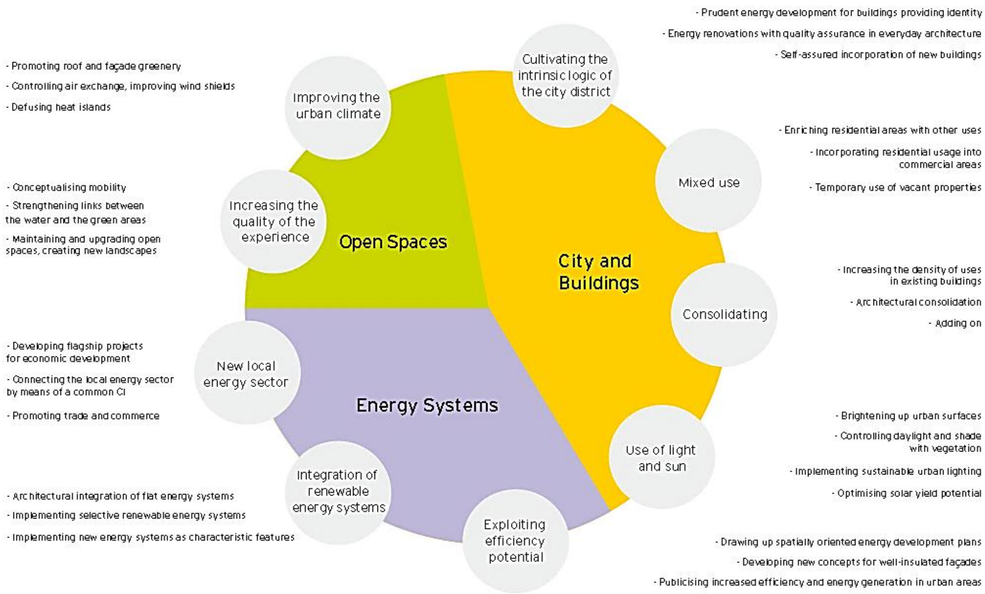


Figure (4.52): IBA's spatial energy concept
Source: (IBA Hamburg, 2010)

9.1. <u>Energy Consumption:</u> The spatial energy concept sets different strategies for climate change management in architecture and urban planning. Basically, those strategies are the focus of the concept road map (IBA Hamburg, 2010):

9.1.1. <u>Urban Scale</u>: The spatial energy concept is promoting and focusing on the exemplary projects and programs which are on the urban planning level and on the urban social level. The spectrum of activity ranges from improving public space for creative neighborhood development and new models of integrated housing construction (IBA Hamburg, 2010).

I. <u>Orientation:</u> The action plan encouraged the good orientation, in order to get the benefits of the sun and the wind, as well as achieve more energy benefits. Besides, future energy planning can contribute to a further increase in building's orientation, solar potentials in order to improve the buildings' exposure to daylighting, as well as helps to prevent undesirable wind currents in the long term as well, as shown in figure (4.53) (IBA Hamburg, 2010).

Figure (4.53): Actions promote the building's orientation in order enhance its exposure to daylighting
Source: (IBA Hamburg, 2010)

II. Wind Direction and Velocity: like many other urban areas, the supply of fresh and cold air is hardly a problem for Wilhelmsburg. In contrast, exposed urban areas and high average wind speeds can create unpleasant conditions. Thus, the concept depended on using intelligent building measures and wind barriers to make a major contribution in the open areas over long periods of time without compromising the access to fresh and cool air. Besides, future planning can also contribute to a further decrease of the undesirable wind currents (IBA Hamburg, 2010). Figure (4.54) shows the IBA spatial actions in order to improve windshields.

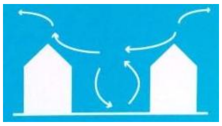


Figure (4.54): IBA spatial actions in order to improve windshields
Source: (IBA Hamburg, 2010)

III. The Exterior Environment: The action plan encouraged the using of white light colored in the surrounding environments, in order to avoid the formation of urban heat islands in the summer and micro temperatures inversions in street canyons. On the other side, the plan also encouraged the removal of the hard surfaces in the open spaces, in order to neutralize the heat island effect. As well as, it encouraged the concept of using unpaved surface, as it is widely known that unpaved surfaces help in improving the urban climate (IBA Hamburg, 2010). Figure (4.55) shows the IBA spatial actions in order defuse heat islands by the exterior surfaces.

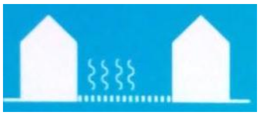


Figure (4.55): IBA spatial actions in order defuse heat islands by the exterior surfaces
Source: (IBA Hamburg, 2010)

IV. Solar Radiation: The plan served as a guideline for optimizing solar yield potential by differentiating in the building's height. Actually, these largely homogenous building heights, helps in reducing the mutual shading of the buildings, which provides ideal conditions for the use of the buildings' facades and roof for renewable generation, as well as a thermal energy collection (IBA Hamburg, 2010). Figure (4.56) shows the IBA spatial actions to optimize solar yield potentials.

Figure (4.56): IBA spatial actions in order to optimize solar yield potentials
Source: (IBA Hamburg, 2010)

V. Block Density: urban planning techniques in this example, focused more strongly on the ideal of the consolidation, in order to achieve energy efficiency targets by this dense city. Thus, Wilhelmsburg's spatial energy concept promoted a lot of projects through planning techniques, in order to increase the density in the areas. Among those measures are: increasing utilization density in existing buildings, architectural consolidation, adding on. The first step was increasing utilization density in existing buildings, the plan contributes to the better utilization of the existing technical and social infrastructure to make the benefits of urban living more tangible. It's worth mentioning that, there were utilization reserves within the inventory of existing buildings, the plan encouraged the new groups of users to make use of the empty ground floor flats in order to accommodate to the commercial units. Besides, the plan also promoted the concept of yielding additional building spaces, as wherever there are vacant properties and unused urban spaces, a new building setting to better utilization of the existing infrastructure. In addition to that, also in the low density urban areas, especially the post war neighborhoods, the plan allowed the building additions and extensions. The utilization of the attic floors and the incorporation of additional floors can help in enriching the neighborhoods's social mix, with little effort and without affecting the existing building. Figure (4.57) shows the different measures in order to increase the consolidating such as: (IBA Hamburg, 2010).

Figure (4.57): IBA spatial actions in order to increase the urban density
Source: (IBA Hamburg, 2010)

VI. Landscape: The plan promoted the concept of enhancing the quality of the urban experience, this can be done by maintaining open spaces, creating new landscapes, as well as strengthening links between the water and the green areas. Furthermore, the plan encouraged the concept of using properly planned urban vegetation, in order to create a heterogeneous micro climate and make a major contribution to summer heat insulation in urban spaces and buildings which consequently decrease the rate of the energy consumption, while supporting the biodiversity and environmental productivity. On the other side, the new landscape areas are very characteristic with the landscape image of the Elbe Islands and to the islands energy supply concept through the long term use of wasteland as an energy landscape (IBA Hamburg, 2010).

VII. Water Features: The IBA action plan strength the link between the water and the green areas, as well as encouraged the using of the water areas, in order to increase the evaporating cooling effects and improve the urban climate in the same way. Figure (4.58) shows the IBA spatial actions in order to strength the link between the water and the green areas (IBA Hamburg, 2010).

Figure (4.58): IBA spatial actions in order to strength the link between the water and the green areas
Source: (IBA Hamburg, 2010)

VIII. Exterior Block Properties: It's worth mentioning that, the action plan encouraged the using of light colored roofs and building materials, in order to create an urban canvas of contrast for historical building, reducing the need for artificial light in urban spaces and buildings, as well as reducing summer cooling requirements. Actually, the light color are the major component of urban identity within the city, as those light colors take a very special significance in temperate climate regions, with long winters and prevailing diffuse solar radiation. Also, it improves not only the daylighting conditions, but also the people's moods (IBA Hamburg, 2010).

9.1.2. Architectural Scale: Hamburg wants to increase energy efficiency in the building sector. The carbon reduction goals call for a substantial reduction in energy consumption by buildings, in particular in heating and hot water requirements and for the use of renewable and climate friendly combined heat and power systems (CHP) for the remaining energy requirements. Performance of Buildings, is that 'nearly zero energy buildings' or "Passive House Plus the only may be constructed, having very low energy requirements covered to a significant extent by energy from renewable sources. This standard not only limits heating and electricity demand to a maximum, but also requires extremely good insulation of the building envelope, plus the installation of highly energy efficient technical facilities. On the other side, the IBA took its first step in 2008, in which it focused mainly on the energy consumption of existing buildings, thus a great effort done to increase the rate of renovation, especially in the private, municipal and co-operative housing sectors. On the other side, Hamburg's climate change mitigation regulations was developed with the aim of achieving an environmentally sound and socially acceptable renovation of existing buildings (IBA Hamburg, 2010).

I. Walls: According to IBA’s spatial energy concept, a great effort had done to enhance building shell renovations, which mainly consist of the roof, windows, as well as façade, thus in order to reduce energy consumption. On the other side, all the new building will be built according to the passive house techniques or meet the requirement of the zero energy house, thus all the technique properties for achieving well design building shell will be applied, such as the required u value and the suitable material. Also, it is quite to mention that, there is a new direction to use of intelligent building materials of the future, such as the smart material. Besides, the plan also promoted the concept of using green façade, as it has a positive impact on urban climate, as they reduce building’s respectively to long wave radiation in summer and avoid the overheating of the interiors (IBA Hamburg, 2010).

II. Roof & Ceiling: As previously mentioned that, the IBA’s spatial energy concept, focusing on enhances building shell renovations, thus all the existing building’s roof will be renovated to enhance the energy requirement. On the other side, all the new building will meet the highest energy efficient technical facilities in the long run. In addition to that, the strategy also promoted the concept of using green roofs in order to improve the city’s climate, preventing urban heat islands and also increase the green spaces. Besides, those green roofs can reduce the building’s cooling requirements, as well as get use of the rainwater (IBA Hamburg, 2010).

III. Openings: The renovation of the openings of the existing building is also within the renovation strategy for the IBA’s spatial energy concept. These elements will be renovated to meet the energy requirement. Besides, all the new building will meet the highest energy efficient technical facilities by using energy effect windows (IBA Hamburg, 2010).

IV. Insulation: The action plan mainly depended on increasing the rate of the insulation for the facades, as it depended mainly on using standard solutions and specific materials to reach their goal for energy efficiency in the inexpensive way. It's worth mentioning that, it aimed to reduce energy consumption by renovating of the existing buildings, also by developing new concepts of heavily insulated façade systems for all the new building (IBA Hamburg, 2010).

V. Natural Ventilation Systems: The action plan optimized the good venation within the buildings, in order to reduce the building’s heat load, as well as increased energy benefits. Besides, there is another concern to reduce energy consumption, which is promoting the using of ventilation ducts which meet the highest energy efficient technical facilities (IBA Hamburg, 2010).

VI. Daylighting Techniques: The plan encouraged the using of the daylighting techniques within the buildings, as well as optimized solar energy developments in order to increase the energy benefits and decrease the dependent on the artificial lighting (IBA Hamburg, 2010).

VII. Shading Devices: Lastly, the spatial energy concept also promoted the using of sunshade devices, in order to reduce energy consumption. As well as, it depended on the vegetation in order to provide extra shading and enhance the urban climate, as shown in the figure (4.59) (IBA Hamburg, 2010).

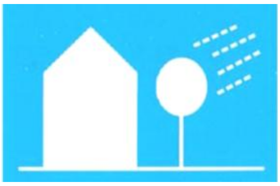


Figure (4.59): IBA spatial actions in order to control shading with vegetation
Source: (IBA Hamburg, 2010)

9.2. Energy Distribution: It's worth mention that, if the city wants to set the right course, it needs to take more control of the energy grids and networks. Thus, it is planned to implement in the future an integrated energy network by smart use of innovative technologies in power supply facility engineering, in connection with building modernization and the integration of innovative control procedures for power grids, such as smart grids. In addition to, decentralized systems which also play a major part in increasing the share of renewables in heating, particularly the use of solar heating systems. Nowadays, it is currently examining the needs for adaptation of the energy grids in the future, in order to meet the climate goals (IBA Hamburg, 2010 & Mebus, 2011).

9.3. Energy Generation: In order to meet the climate goals, low-emission fuels and renewables are to be used more for the future generating structure for district heating supply. In Wilhelmsburg there is a range of options for using renewable energy source such as solar and wind energy, geothermal energy, biomass and biogas. The measures apply especially to innovative energy supply concepts, which promote the use of renewables (IBA Hamburg, 2010 & Mebus, 2011).

- **<u>Off-site Renewables:</u>** No resources will be consumed from outside the IBA district area. As the main target is to meet the entire required energy demand from on-site sources. This can be done by adding more decentralized renewable energy productions within the area, in order to reduce ecological energy footprints (IBA Hamburg, 2010).

- **<u>On-site Renewables:</u>** It worthwhile to consider that, the IBA's Focuses on renewable energy that ideally does not require additional space. The plan concentrated on certain forms of renewable energy production, that are invisible in the urban environment. Thus, a special focus is promoting the using of the urban infrastructure and lands for solar energy, such as they can use the noise barriers, landfill areas, roof canopies over parking areas, bus stops, public squares and many more. On the other side, utilize building surfaces for photovoltaic units, thus no new buildings or energy renovation without consideration of photovoltaic technology, all the building should exploit every opportunity for producing energy through their own power generation, such as using their facades and their roofs for photovoltaic and solar thermal energy (IBA Hamburg, 2010). In general, there are common renewable energy potentials available in the IBA area, as shown in figure (4.60). The following part shows the integrated energy network within Wilhelmsburg, such as:

  - Wind: Only large scale wind power stations are taken into consideration in the IBA area, small scale wind power is discarded on the grounds of low efficiency and adverse urban environment impact.

  - Photovoltaic and Solar Thermal Technology: A special focus is placed on units that are integrated within the building shell. Open area units take up extra place space when located in unusable space such as disposal sites.

  - Geothermal Energy: It worthwhile to mention that, it is limited within IBA area due to the specific geological condition, thus there are 3 homogenous distinguished drilling areas.

  - Wastewater Heat Recovery: It is carried out in the IBA area by means of shafts directly on the building. It is only economically viable in buildings with more than 30 housing units. There are practical projects have since shown that, all the domestic waste water can be used to meet the generation of electricity and heat requirement within the buildings.

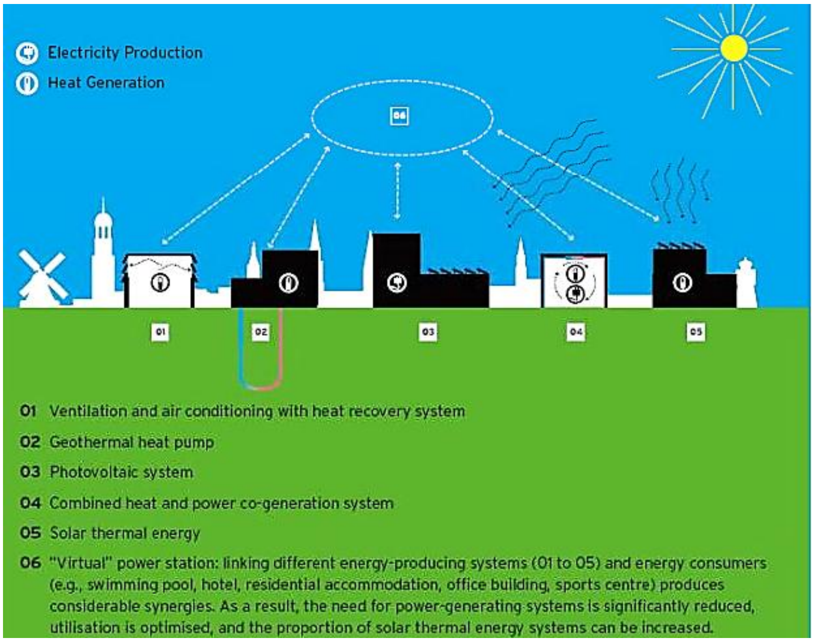


Figure (4.60): Integrated energy network within Wilhemsburg
Source: (IBA Hamburg, 2010).

- **Observation on Future Concept Renewable Wilhelmsburg:**

Seven years after the IBA was founded, Hamburg's Elbe Islands are well on the way for making the transformation from a city backwater to a prime example of urban renaissance. The analytical methods used here are the basis for urban action strategies, which can be applied more generally, in order to demonstrate how cities in particular can become the pioneers of climate protection and resource conservation. The following part discusses some of the pros and cons of these analytical methods:

- Pros: It's worth mentioning that, even after the IBA Hamburg comes to an end, over 60 projects live on as showcase projects which fulfil a number of quality criteria. All of these projects are characterized by originality and practicality in utilization. Those projects also will serve as a benchmark for the whole of Hamburg and for other cities worldwide. Thus, with the IBA, Hamburg there is a special opportunity to be able to develop concepts for the most pressing challenges for urban development which decisively affect the future of the cities, such as globalization, migration, economic dynamics, ecocide, shortage of resources and the impact of climate change (IBA Hamburg, 2010).

- Cons: While on the other side, some experts proved that, there are some flip-side of this transformation such as:

1. The fear about the displacement of the original residents. As, Wilhelmsburg a became a district for everyone in the future and thus it loses its stigma. In general, it became a mixed lively urban district in which people of all races and ages enjoy living (Sassen, 2013).
2. With this transformation Wilhelmsburg has changed in just six years, which has given rise to the rate of the rents and also the crowding. In general, it is obvious now in Wilhelmsburg that rents have risen comparatively more than in other similarly poor boroughs of Hamburg (Sassen, 2013).
3. Another negative concern that the IBA provided a tight framework for investment. Consequently, no private partners had been found by the end of 2008 (kreichauf, 2013).
4. Nowadays, the Elbe Islands are not considered to be a suitable location for private housing investment. As, there is only one housing company was prepared to implement a model project, which is the “Global Neighborhood” project (kreichauf, 2013).
5. Unfortunately, the IBA was not able to overcome every political or administrative hurdle. As an example was the traffic plan, which devised in 2011 by the Urban Development Department of the Ministry for the Economy Transport and Innovation. The lack of overall transport planning was detrimental to the IBA’s urban development plans due to public transport policy decisions (Sassen, 2013).

- The overall ability of the city to succeed:

With the start of the project no one was expecting just how successful the development of the Wilhelmsburg maturation would be in unleashing the potential for urban development and bringing about the residential construction that was so urgently required. Nowadays, Wilhelmsburg becomes an attractive residential neighborhood close to the inner city into which many key services have relocated. The various projects and concepts have been the key to the success of the IBA Hamburg. Also, the record of the consumption savings is another reason, as by 2010, about 70% of the intended reduction was delivered. This means that, it is possible to meet their reduction goals (IBA Hamburg, 2010).

4.7. El Gouna (Hurghada, Egypt):

El Gouna has been officially recognized as the most environmentally friendly holiday destination in Egypt. It is an example of an existing city which was not originally planned as a sustainable city, but it progressed to decrease its impacts on the environment. It's worthwhile to mention that, it started with a few villas around a small hotel. The echo trend started in 2005 and as it grew its environmental consciousness grew with it, until it became quite fashionable to be environmentally conscious, not only in the circles of celebrities and public figures, but also in businesses. The town's environmental programs and grassroots environmental organization paved the way for several awards, including the Green Globe. Besides, El Gouna has selected as the pilot location for the Green Star Hotel Initiative. Also, it has won awards for its architecture and environmental quality that brings together traditional elements of the land's rich heritage with modern design and functionality (Abaza, 2013 & Prime living, 2013).

- Background & Overview:

El Gouna is a private, self-sufficient city, which it is located 25 km north of the Hurghada International Airport. It was initiated in 1990 by the privately owned Orascom Hotels and Development Company. El Gouna Established more than 20 years ago and was built along 10 kilometers of beachfront. It extends across a countless number of islands and beautiful lagoons. The city is now a home to the population between 22,000 – 24,000 permanent residents and visitors from all over the world, to whom it offers a wide range of international standard facilities. The city represents as a creative and diverse community of entrepreneurs, artists, environmentalists, sports enthusiasts and families (Orascom Development Holding, 2011 & Abaza, 2013).

- El Gouna Vision:

It is worth mentioning that, El Gouna is quite simply an environmentally friendly. Orascom Company started working on reducing their carbon footprint as early as 2002 and they committed to become a beachside resort with applying zero waste, energy saving, green principles, but without compromise on comfort or style (Abaza, 2013). The goals of the Green Gouna are the development of the resort to be as an ecotourism destination. It's worthwhile to consider that, in order to pursue those goals, the community was involved in establishing the environmental standards and guidelines through education, recycling, clean-up campaigns, as well as festivals (Orascom Development Holding, 2011). It has been mentioned that, Orascom Group was the first who take the risk and provide the financing, they created this flagship project in order to stand out and match the trend of being environmentally friendly. They planned to develop El Gouna, in order to reach a something that is quite successful without even burdened the government. On the other hand, it was being developed to be the Orscoms' gift to the Egyptian government, as the government can take what they have done so far and replicate it (Prime living, 2013).

- El Gouna Vision towards Sustainable Development:

El Gouna has voluntarily committed itself to sustain the development that maintains the natural beauty of its location. All the community management members have worked hard in cooperation with the local hotels, businesses, residents and visitors to maintain, protect and preserve its unique environment (Prime living, 2013). Also from the other side, Orascom created their Blossom Formula Strategy, this strategy is mainly based on the triple spheres of the sustainability, in which the project is supposed to encompass the three features which are the social, ecologic and economic. It's worthwhile to mention that, El Gouna is the first project for which Orascom is applying their Blossom Formula Strategy. They regarded this development as a process, which still demands great concentrated effort on their part, in order to achieve their concept designed to guarantee the sustainable development of El Gouna by 2020 (Orascom Development Holding, 2011). Figure (4.61) shows the time line for the development of El Gouna in relation to the Orascom Blossom Formula Strategy.

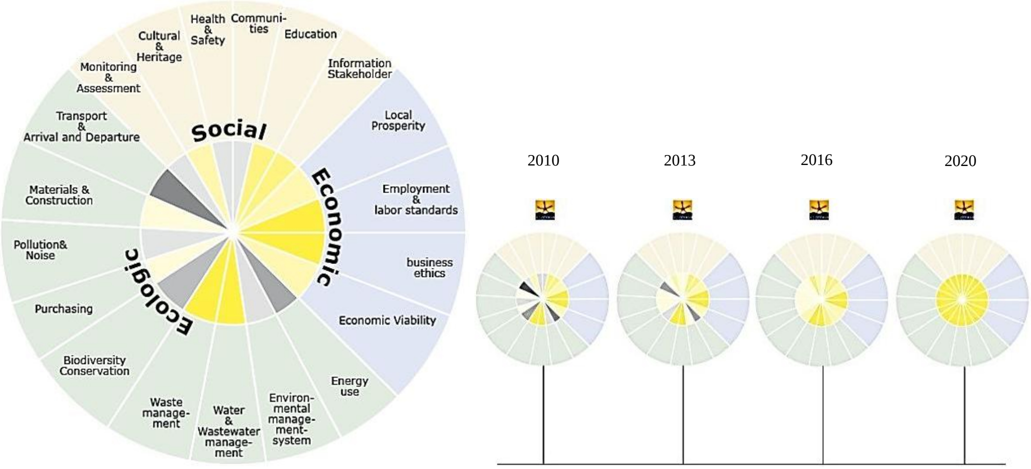


Figure (4.61): Orascom Blossom Formula Strategy
Source: (Orascom Development Holding, 2011)

- <u>Environmental Aspect:</u>

According to the current status, El Gouna aimed for high ecological, economic and social standards based on the triple spheres of the sustainability. The concept has been designed to guarantee the sustainable development of El Gouna (Orascom Development Holding, 2011). To raise awareness and highlight the importance of this, El Gouna developed the Green Star Program with the same concept of the regular hotel star ratings, except that it ranks hotels on how environmentally friendly they really are (Prime living, 2013). The following part is a brief description of how the city meets its goals to become environmentally friendly:

1. <u>Land-Use System:</u> El Gouna's uniqueness as a destination lies in the fact that the town serves both as a vacation resort and as a well-established community. It is a self-contained town, services all the basic needed for comfortable living and convenience. It offered a wide range of international standard facilities such as entertainment facilities, commercial facilities, as well as healthcare, as shown in figure (4.62) (Prime living, 2013). Besides, being touristic destination, it considers as a cultural hub with a public library affiliated to the world famous Bibliotheca Alexandrina. Also, it can be considered as an educational pole with university facilities, such as American University Field Study Center and the TU Berlin El Gouna Campus. Besides, other international and Egyptian schools, international hotel schools and nursing institute (Orascom Development Holding, 2011).

Figure (4.62): El Gouna master plan
Source: (Prime living, 2013)

2. <u>Waste Management:</u> El Gouna practices garbage separation and recycles materials locally. The city developed this recycling process that recycles and reuses everything that comes out from all kinds of waste (Orascom Development Holding, 2011). It is a centralized process, whereas all the waste is collected daily from the different houses, villas, hotels and then fully recycled at a central on-site recycling plant. The city's waste and garbage are sorted and separated at source in colorful bins, in which each bin is special for different kind of material, such as one for plastic, cans, glass as well as paper, as shown in figure (4.63) (Prime living, 2013). Then they recycled into a different kind of other materials, such as plastic is recycled into construction materials and in clothes hangers which are used in all of the rooms. Paper and carton turn in carton bags and other paper products that are used in supermarkets and gift shops. On the other side, 25% of the solid waste is recycled in El Gouna, as it is processed into compost and used to feed farm animals and fertilizer for the landscaping (Abaza, 2013).

Figure (4.63): Colorful bins for separating wastes
Source :(Prime living, 2013)

By the end of the day El Gouna implemented a zero waste management system, which designed to recycle 100% of its waste, but in fact this system only recycled 85% of El Gouna waste. The reason for that, El Gouna was growing and the waste was growing and it was very hard for them to constantly keep up with their demand. In the last decade, they met the target of recycling 100% of all the trash, but suddenly the trash was increasing and it was very hard to scale up and recycle 100% of the waste at every single point (Abaza, 2013).

3. <u>Mobility System:</u> The city aimed to minimize fossil fuel consumption regarding transportation within El Gouna, that by encouraging the lower energy mobility (Orascom Development Holding, 2011). It's worthwhile to mention that, El Gouna is one of a few places in Egypt that, developed a special lane for biking and walking. It encourages people to ride a bike and to walk, instead of taking buses, limousines and their own cars that burn fuel (Abaza, 2013). It also offers a variety of transportation

options within the resort, from regular shuttle buses transport tourists to and from the beach, motor bikes, as well as there are rickshaws that can be also used for a fee(Prime living, 2013). Figure (4.64) shows the different kinds of transportation within El Gouna.

Figure (4.64): Different kinds of transportation within El Gouna
Source: (Prime living, 2013)

4. <u>Water Management:</u> In El Gouna, there is a water purification plant located in the town. The plant partially cleans the sewage water from all of the hotels, resorts, homes and then used it as grey water to irrigate all of the green areas and golf courses throughout the resort in an effort to conserve water. While the solid part of the waste water is used as compost to fertilize the soil. On the other hand, instead of using fresh water that is supplied by the government, El Gouna supplies their own water by desalinating water from the Red Sea and from well water. Besides, the city also installed water saving fittings on water outlets in all the hotel's guest rooms (Orascom Development Holding, 2011& Prime living, 2013).

5. <u>Food System:</u> In an act of self-sufficiency, El Gouna created a certified organic farm where they grow local organic products, as well as a fish farm that makes use of the rejected water from the desalinating units. It's worthwhile to consider that the town's food waste goes to feeding farm animals and all the reject water from the desalinating units are used in the fish farms (Prime living, 2013& Abaza, 2013).

6. <u>Materials Conservation:</u> The city use locally appropriate principles of sustainable construction such as local materials, recycled materials. As an example the city use recycled waste to pave our sidewalks, bridges and streets. Besides, the city also aims to purchase local and fair trade services and goods, as well as its challenge its' suppliers and other business partners to improve their practices (Orascom Development Holding, 2011).

7. <u>Natural Systems:</u> In an act of environmentally friendly, El Gouna created a plan for biodiversity conservation. The city mainly used the native plant species for landscaping,

such as acacia, casuarina and mangrove trees, which can tolerate the desert weather and the salty soil. On the other side, the organic farms are created which provide an insect habitat and in turn supports birdlife. The city also put rules to support natural protected areas and areas of high biodiversity value, in order to minimize any disturbance of natural ecosystems (Orascom Development Holding, 2011). From another perspective, El Gouna provided for the diving boats a mooring system, which has been installed in cooperation with the Hurghada Environmental Protection and Conservation Association. But in fact, all of these activities such as diving and snorkelling, take a role in destroying the Red Sea's marine ecosystems, particularly its coral reefs. Also the town's artificial lagoons with the houses and hotels surrounding the shores, are mainly having a negative impact on the country's natural environment (Eakin, 2012).

8. Housing: The city has a different mix of housing types, sizes and density, such as villas, apartments, twin villa and this actually refers to the affordability and diversity of the housing stock. Besides, there are adorable units to ensure equity and to create a socially and economically diverse society (Orascom Development Holding, 2011).

9. Energy Efficiency: Great efforts to conserve energy are implemented by El Gouna throughout the whole town. The city encourages the use of energy saving lamps and solar water heaters at hotels, villas and apartments. Besides, the majority of the hotels is already using the energy saving cards (Orascom Development Holding, 2011). Furthermore, the city also planed to use a carbon-free energy supply system for the entire resort by using renewable energy sources (Abaza, 2013).

9.1. Energy Consumption: Orascom Development is firmly committed to the long term sustainability of its towns. From the earliest planning stage, they consider every aspect of the community's needs, from facilities and infrastructure (Orascom Development Holding, 2011).

9.1.1. Urban Scale: It's worth mention that, there are a lot of characteristics, which have converted El Gouna to be one of the most exclusive and desirable holiday locations. Among those characteristics are the unique careful choice of the location, the sustainable and environmentally friendly layout, as well as the infrastructure and planning facilities (Orascom Development Holding, 2011).

I. <u>Orientation:</u> As mentioned before that, El Gouna is characteristics by its' sustainable and environmentally friendly layout. It has been taken into consideration that the majority of the buildings are well designed according to their site location, in order to get the best use of the privilege wind and the sun which are available at the site (Orascom Development Holding, 2011).

II. <u>Wind Direction and Velocity:</u> As described previously that, the majority of the buildings are well designed according to their site location, in order to get the best use of the privilege wind at the site (Orascom Development Holding, 2011).

III. <u>The Exterior Environment:</u> It was obvious that, the majority of all the buildings and the sidewalks are mainly used high-albedo materials and that will directly affect the indoor and outdoor thermal comfort, which reduces the energy demand for cooling in the summer, as shown in figure (4.65). Besides, the recycled waste materials are used to pave the sidewalks, bridges and streets, this mainly reduces the energy consumption within the district (Orascom Development Holding, 2011& Prime living, 2013).

Figure (4.65): Sidewalks' material within El Gouna
Source: (Prime living, 2013)

IV. <u>Solar Radiation:</u> As the city located in a harsh desert climate, in which it is characterized with hot, arid zone, with a very wide difference between day and night temperatures. Comfortable indoor and outdoor spaces have been carefully sun protected and any surface exposed to direct sunshine have been well designed according to the sun orientation. Besides, all the buildings are covered with domes and vaults, in order to decrease the absorption of the sun radiation and improve the interior climate. As it is widely known that, the domed and the arched offer an advantage over the flat roof (Orascom Development Holding, 2011& Prime living, 2013).

V. <u>Block Density:</u> The city's design is compact, with low rise buildings from 3 to 4 storeys. It has been taken into consideration that the character of the city development is derived from the traditional rural Egyptian context (Orascom Development Holding, 2011& Prime living, 2013). The following figure (4.66) shows that the compact design of the city.

Figure (4.66): El Gouna City is characterized by its' compact design
Source: (Prime living, 2013)

VI. <u>Landscape:</u> The landscaping options provide the minimum landscaping requirement to ensure that the community is as a lush green oasis in the midst of the desert. The city used the native plant species for landscaping, such as acacia, casuarina, eucalyptus, tamarix and mangrove trees, which can tolerate the desert weather and the salty soil. Also, the landscape courtyards are used to maximize the cooling effect inside the buildings, as shown in figure (4.67) (Orascom Development Holding, 2011& Prime living, 2013). Figure (4.68) shows an example of the efficient design of the landscape design of one of El Gouna's resorts, which is Ancient Sands Golf Resort.


Figure (4.67): Courtyards within El Gouna City
Source: (Ancient Sands Golf Resort, 2009)

Figure (4.68): Ancient Sands Golf Resort
Source :(Prime living, 2013)

VII. <u>Water Features:</u> The city covers 10 km of beachfront and over 20 islands surrounded by lagoons, as shown in figure (4.69). This large amount of water takes up a large amount of heat in evaporation and causes significant cooling, especially in a hot climate like El Gouna (Prime living, 2013).


Figure (4.69): El Gouna City is characterized by a large area of water
Source: (Prime living, 2013)

VIII. Exterior Block Properties: The majority of all the buildings is mainly used high-albedo materials, which will directly affect the indoor and outdoor thermal comfort and reduces the energy demand for cooling in the summer. From another side, the building form and mass help in minimizing adverse wind effects which directly minimize the overall energy consumption requirements (Prime living, 2013).

9.1.2. Architectural Scale: El Gouna is a blend of different styles and colors, strongly wanted to create a well-studied balance of elements. Great lengths have been taken to ensure that the town and its buildings conform to the highest architectural standards (Prime living, 2013). The resort's award-winning architecture incorporates a blend of traditional and modern elements and is the work of an impressive list of prestigious architects, including Italian Alfredo Freda and American Michael Graves (Orascom Development Holding, 2011).

I. Walls: It worthwhile to consider that, the comfort of people inside buildings in this district depends largely upon the thermal properties of the walls and roof. The buildings are constructed with locally manufactured materials such as clay and natural stone with thickness from 50-60 cm, as shown in figure (4.70). Such building materials conserve energy and improve all environmental practices. In addition to that, these materials minimizes the noise pollution from different resources as well as reduces the indoor temperature (Abaza, 2013& Prime living, 2013).



Figure (4.70): Shows that the buildings of El Gouna City are constructed from local materials
Source: (Prime living, 2013)

II. Roof & Ceiling: Buildings were covered by domes and vaults, in order to provide the interior with moderate climate, as shown in figure (4.71) (Prime living, 2013).


Figure (4.71): El Gouna buildings are covered by domes and vaults
Source: (Prime living, 2013)

III. Insulation: The building’s walls were constructed with locally manufactured materials with thickness from 50 cm to 60 cm, which used as insulation for the indoor. Thus, the design did not need to add extra insulation, the wall itself is the insulation element (Prime living, 2013).

IV. Daylighting Techniques: The majority of the building did not depend mainly on using daylighting techniques in their design. But on the other side, there are some buildings use some opening in the dome design to provide more daylight inside the building, but they represent a very small ratio compared to the whole buildings (Prime living, 2013).

V. Natural Ventilation System: The buildings shape is compact with wide width, this means that the building shape is not efficient to provide cross ventilation. And on the other side, the buildings’ design did not depend on using added techniques to enhance ventilation inside the building, such as solar chimney or wind cowls. But on the other side, there are some buildings depended on their design on the courtyards which somehow enhance the natural inside the building (Abaza, 2013& Prime living, 2013).

VI. Openings: The buildings depended in their design on the recesses, rounded shape windows, which are well designed according to the orientation. Besides, the east-west facing windows were limited in size in the buildings. Also, there were some buildings depended on their design in using the mashrbaia (Prime living, 2013). Figure (4.72) shows examples of the window shapes in Ancient Sands Golf Resort.

Figure (4.72): Shows examples of the window shapes in Ancient Sands Golf Resort
Source: (Ancient Sands Golf Resort, 2009)

VII. Shading Devices: As the city located in a harsh desert climate and the climate is characteristic of a hot, arid zone, thus the majority of the buildings used shading elements in different shapes to provide the shading on the building and improve the indoor and outdoor thermal comfort (Orascom Development Holding, 2011). On the other side, the design of the buildings' form used to provide shading on each other. Figure (4.73) shows some example of the El Gouna's building which using shading elements.


Figure (4.73): Shows examples of El Gouna buildings which used different shading elements
Source: (Prime living, 2013)

9.2. <u>Energy Distribution:</u> According to the financial aspect the city does not have a vision for the smart distribution system. May be in the future the city can be provided a smart or intelligent grid, as well as intelligent smart building (Abaza, 2013& Prime living, 2013).

9.3. <u>Energy Generation:</u> The city planned to use a carbon-free energy supply system for the entire resort by using renewable energy sources.

- **<u>Off-site Renewables:</u>** It is quite important to mention that, the city achieves a reduction in the consumption of non-renewable resources by exploiting the wind power found in Hurghada (Orascom Development Holding, 2011). Also, some of the energy used in the city is generated using the horizontal wind turbines found in farms around the city. Those turbines are located on the shore with a good wind regime which offers a good condition for the operation of the wind turbines (Prime living, 2013).

- **<u>On-site Renewables:</u>** In addition to the wind turbine farms which are located around the city, the city encourages the use of solar water heaters to heat water at all the hotels, villas and apartments (Orascom Development Holding, 2011). It can be stated that, a city like El Gouna can be easily converted into a zero carbon city. However, increasing the internal costs of applying on-site renewable energy technologies, can be represented a financial barrier and a technical constraint of turning exiting cities like it into a zero carbon city (Abaza, 2013).

- **<u>Observation on El Gouna:</u>**

At the end, it's worth mention that, currently El Gouna has voluntarily committed itself to sustain the development that maintains the natural beauty of its location. Although, the goal of the Green Star Hotel Initiative to standardize El Gouna to be a model that encompasses both ecological and economic aspects, the project has some of the deficiencies and positive points (Abaza, 2013& Prime living, 2013). Among those points are:

- <u>Pros:</u> It's worth mentioning that, it can stand as a model to become a truly green destination, which assuring a unique advantage to be applicable among global tourist destinations, as well as it can create a promising future for the tourism industry. Also, according to the Green Star Hotel Initiative, which has been developed in 2002, El Gouna can be represented as a national pilot for an environmentally friendly label for hotels and resorts. This label can be applied to all the destinations throughout Egypt and the Middle East. Also, it can raise the percentage of the awareness for environmental protection among the hotel guests, tour operators, hotel staff and residents (Orascom Development Holding, 2011).
- <u>Cons:</u> Although El Gouna represents as a good step in Egypt, there are some experts criticize the project and found some deficiency points in it, such as:

1- Although the tourism movement in the Red Sea of Egypt has benefited the economy financially, this has unfortunately been accompanied by degeneration in Red Sea’s marine ecosystems, which resulting in the death of the coral reefs, loss of the habitat structure, as well as fish reduction. The site is suffering from physical damage to the natural resources in the region, this damage was primarily a result of anchor and diver damage, as well as other activities such as the scuba diving and snorkelling. The great efforts which should be done to preserve and protect the health of Egypt’s coral reefs are not only important for sustaining Egypt’s tourism economy, but also for buffering the Red Sea coastline against waves, storms and floods. Thus, according to this critical reason El Gouna can only be a good model for development, but not environmentally sustainable (Eakin, 2012).

3- According El Gouna’s vision, the city would recycle 100% of its waste, but in fact this system only recycled 85% of El Gouna waste. The reason for that, El Gouna was growing and the waste was growing and it was very hard for them to constantly keep up with their demand (Abaza, 2013).

4- Although it was a good step that, El Gouna has its own desalinization plant, the process has its own environmental drawbacks. As, the desalinization process also creates its own effluent called brine. The brine is very salty and when released back into the ocean, it has a negative impact on the level of the water, which harming the coral reefs. But this problem may be minimized after the fish farms have been created by the water coming from its desalinization plant (Eakin, 2012).

5- It's worth mentioning that, all the hotels in El Gouna are green star certified. Although this is an international standard for labeling hotels, which based on certain environmental criteria that hotels must meet, some environmental experts believe that the Green Star Hotel Initiative is not a serious initiative and not enough to qualify Gouna as a truly sustainable tourist destination (Eakin, 2012).

- <u>The overall ability of the city to succeed:</u>

El Gouna city has succeeded to achieve the natural, cultural and technical images of sustainability. Besides, the project as a whole gives the many challenges to creating a truly sustainable tourist destination. Although the final project or the final outputs proved that, the city can only be described as a good model for development, but not environmentally friendly according to the present of some deficiency points. But, there is a room to improve it and might take time for Orascom' vision to fully manifest. Thus, Orascom Development should make great effort and use more green energy to reach the concept of zero carbon cities while decreasing its impact on the environment (Eakin, 2012& Abaza, 2013)

4.8. <u>Conclusion:</u>

According to the analysis findings of the number of the projects which attempted to develop sustainable approaches in general and energy efficiency in particular, it can be concluded that the issue of sustainability is very subjective. Also, there is no approach or framework that is ultimate and definitive for all the projects. Each one of the them has its own advantages and disadvantages, this may be due to the vast differences between the master plan of each project and also due to the differences in the scope and the time frame of each one. This makes the comparison of the sustainability theme as a whole among these cities is very difficult, as well as not easy to declare which city is more sustainable than another. But there is an agreement that, there is a common vision in the majority of the projects, which is their adaptation to most of the sustainable strategies in order to capture the rising concerns about the future of the natural, economic and social environment. In general, the analysis showed that, the sustainable approach cannot be solved only by technical solutions, but needs rethinking of the lifestyles.This means a change in the daily behavior in respect of mobility, comfort expectations, water, energy and material consumption and waste production. Moreover, all of the projects agree on the concept of addressing issues on a community scale rather than individually, which means that, there is a big need for holistic thinking.

At the end, it was obvious that, the move towards sustainability in cities is critically important because cities have extremely large environmental impacts. Thus, the following concluded comparison table presented a brief analysis of all the examples in order to create the good and bad practice guides solutions. The points of the analysis that will be discussed in each example are evaluated in two scales. The first scale analysis the examples according to the sustainable neighborhood principles, while the second level analysis them according to the energy efficient design principles which have been extracted from the literature review parts (Chapter 1 and 2). Moreover, the analysis also showed the investigations of different tools and methods of planning and assessment of sustainable projects which are based mainly on the concepts of achieving energy efficiency. This can be returned to its importance to identify the similarities and the differences, as well as to reach to an efficient methodology or the ideal proposal of an action, which can then be applied to the local case study within the next chapter. The following table (4.1) analysis the examples according to the following key:

● Existing and Efficient = 1 point

⊖ Existing but not Efficient = ½ point

⊗ Do not Exist = 0 points

Design Principles	Masdar City		BedZED		Hamburg		El Gouna city	
Vision	Masdar city's goal was to build a brand new sustainable city from scratch, in order to position Abu Dhabi as a global leader and a hub for the development of renewable energy, or to position Masdar as the Silicon Valley for green energy. It aimed to be the world's first zero carbon, zero waste, zero car city. It has been designed as an Eco city which only depends on renewable energy power generation.		BedZED's aim was to show that in large scale construction a high level of sustainability can be practical and can be achieved within the cost restraints of a social housing budget..		The main vision was to present an overall model of how a whole district can be transformed to become independent in terms of energy as well as improve the population's quality of life.		The main goals of Green Gouna were to develop the resort to be as an ecotourism destination. Green Gouna pursued those goals by involving the entire community in protection and preservation.	
Selection	Masdar city was taken as an example to examine the notion of model city which seek to set new benchmarks for achieving zero energy community. The example serves as a showcase or a test-bed for unconventional planning methods and renewable energy technologies in order to help in teaching the other communities how to build zero energy cities globally.		BedZED district was taken as an example to examine the notion of model city which seek to create more sustainable living environments and minimize the residents' ecological impact. The example helps the residents live within their fair share of the earth's resources without sacrificing a modern lifestyle.		Hamburg's Wilhelmsburg district was taken as an example for demonstrating how existing cities in particular can become the pioneers of climate protection and resource conservation. The example tried to demonstrate solutions for the urban built up environment which fulfills all the energy requirements by using renewable energies.		El Gouna City was taken as an example to examine how existing cities that were not originally planned as sustainable cities, can make progress to decrease their impact on the environment.	
The Rating System / Indicator Used	The project city has been planned to meets or exceeds each of the requirements of the 10 sustainability principles of the BioRegional "One Plant Living framework".		The project city has been planned to exceed the requirements of the 10 sustainability principles of the BioRegional "One Plant Living framework".		All the IBA's construction projects were trying to apply the requirements which exceed the "German Energy Saving Regulation (ENEV2009)" by 30percent, as these projects targeted to implement the strategies of the "Passive House Plus and the "Zero energy House". In addition to that, there were some projects are also intended to be certified according to the guideline of the "German sustainable Building Council (DGNB)" and achieved its Gold Standard.		The project city has been planned to apply the requirements of the "Blossom Formula Strategy" which is created by Orascom company. This strategy is mainly based on the triple spheres of the sustainability, in which the project is supposed to encompass the three features which are the social, ecologic and economic.	
1. Land Use System	●	The project integrated all aspects of city life, such as work, recreation and home all in close proximity.	⊖	Although the project integrated homes and workspace with different facilities such as sports, clubhouse, childcare facilities, shops and cafes, there was a lack of the public services, such as the school, medical center.	●	The IBA's project applied different concepts in order to achieve mixed utilization within the area, such as: enriching residential areas with other utilization, incorporating residential usage into commercial areas, as well as temporary use of vacant properties	●	It is a self-contained town, which services all the basic needed for comfortable living. It offered a wide range of standard facilities such as entertainment facilities, commercial facilities, as well as healthcare. Besides, it considers as a cultural hub and as an educational pole.
2. Mobility System	●	Masdar will be one of the world's first zero car cities, which applied a sustainable mobility network. • The public transportation network covers all the city within the preferred walking distance, as no destination within the city will be more than 250-300m • Most private vehicles will be kept at the city's edge in a number of parking lots, that will be linked by electric bus routes to other public transportation traversing the city. • Due to Masdar's pedestrian-friendly design, walking and bicycling are expected to be the city's most popular forms of transit. • Some of measures are implemented to encourage the use of public transport such as the light rail, underground personal rapid transit system (PRT).	●	BedZED's aim was to reduce private fossil fuel car mileage by 50% of what would have been expected of a conventional build on the same site • The project has limited the parking space and placed at the edge of the community. • In addition to, a good public transport links, including two railway stations, two bus routes and a tram link. • The project also encourage the using of car club, car pool displaces, as well as encouraged to change to an electric vehicle. • The project also provided a cycle network and pedestrianized areas in the center.	●	Hamburg aimed to increase the share of environmentally acceptable transport, in order to avoid the continuous growth of carbon emissions. • So that, it is improving its public transport systems, also improving the cycling infrastructure, promoting the car-sharing schemes, as well as improving the pedestrian infrastructure and make it more attractive in order encourage walking. • In addition to that, regulations for the purchase of low-emission cars for public authority vehicle fleets are in preparation. • Besides, environment friendly technologies in Hamburg transportation are promoting, such as electric vehicles and environment friendly taxis.	●	• The city aimed to minimize fossil fuel consumption regarding transportation within El Gouna, that by encouraging the lower energy mobility. • El Gouna offers a variety of transportation options within the resorts, such as regular shuttle busses transport tourists to and from the beach, motor bikes, as well as there are rickshaws that can be also used for a fee. • The city also developed a special lane for biking and walking.
3. Waste Management	●	• The project apply the advanced waste and wastewater treatment system, in which all the kinds of waste will be recycled and reused as fertilizers for landscaping, or converted to energy through on-site plant.	⊖	BedZED's aim is about 60% recycling rate by weight of waste including green waste. Separate waste collection systems and the reuse-collection facilities were designed to support recycling on-site.	●	Materials which are generally disposed of, such as the woods and the grass cuttings, were collected in the same areas and then turned into biogas in dry fermentation plants and in order to produce electricity.	⊖	El Gouna implemented a zero waste management system, which designed to recycle 100% of its waste, but this system only recycled 85%. All kinds of waste are collected in separate garbage colorful bins and then fully recycled at a central on-site recycling plant.
4. Water Management	●	• Masdar will derive all of its water from a desalinization plant located just outside the city which will run solely on solar power. • The city's net water demand reduced by 60% in the overall water consumption in comparison to the Abu Dhabi baseline. • In addition to that, 80% of all water in Masdar will be re-purified and recycled by the city's water treatment plant to be as grey water used for household and irrigation purposes.	●	• BedZED sought to reduce treated potable water demand by more than 50% than conventional housing. Also, it sought to treat all of the site's wastewater so that the resulting green water effluent could be reused to flush toilets and irrigate gardens. • This system combined with rain water harvesting, which has saved another 15 liters of mains water per person per day. • Besides, other practices have also been incorporated to prevent excess flows such as using pressure showers, visible meters water-consuming appliances such as dual flush toilets.	●	• Some of IBA's projects mainly succeed in using the water cycle drainage concept. • The rainwater, the black water, as well as the grey water or any other waste water is to be collected, treated and subsequently reused. • Besides, there are practical projects have since shown that, all the domestic waste water can be used to meet the generation of electricity and heat requirement within the buildings	●	• El Gouna supplies their own water by desalinating water from the Red Sea and from well water. • Besides, there is a water purification plant located in the town, which partially cleans the sewage water from all of the hotels, resorts, homes and then used it as grey water to irrigate all of the green areas and golf courses.
5. Housing	⊖	The city includes an appropriate mix of housing types, sizes and density, but there is a lack of planning for affordable housing for the low income which promotes the equity concept.	●	The community incorporates a range of housing types and sizes, as well as the project includes two-thirds of affordable or social housing, which will ensure a variety of different income brackets s live at BedZED	●	The city includes an appropriate mix of housing types, sizes and density. As well as there are a lot of practical examples of the IBA's projects, designed to provide an attractive dwelling for low and middle income classes.	●	There are mix of housing types, sizes and density, as well as there are adorable units to ensure equity.

6. Natural Systems	●	• Masdar objective, according to the natural habitat is that, all the valuable species are conserved or relocated with positive mitigation targets. • In addition to that, vernacular based landscape strategy using local species for reduced irrigation demands and consolidated open spaces and recreational areas	●	There were number of measures which promote BedZED Biodiversity Plan such as using native plants in the roof garden planters and all site landscaping, the features of the buildings have been designed to encourage wildlife, as well as the establish of an ecology park on the adjacent site.	●	• There are many practical projects of the IBA's projects provided the best possible habitat for biodiversity in the urban environment, such as promoted the idea of using green roofs and local frames, as well as provided over 70 hectares of green space. • Besides, they also considered the idea that harbor and nature don't have to be dramatically opposed, thus an integrated network of many small harbors biotopes, has been established, in order to offer the best prospect for a green harbor.	⊖	• El Gouna created a plan for biodiversity conservation. The city used the native plant species for landscaping and also created the organic farms which provide an insect habitat, which in turn supports birdlife. They also put rules to support natural protected areas and areas of high biodiversity value, in order to minimize any disturbance of natural ecosystems. • But, all of these activities such as diving and snorkelling, take a role in destroying the Red Sea's marine ecosystems, particularly its coral reefs. Also the town's artificial lagoons mainly have a negative impact on the country's natural environment
7. Materials Conservation	●	• Throughout the construction process, great measures will be taken to maximize the amount of recycled and certified sustainable building materials with low embodied energy. • Preliminary plans are being made for recycling the concrete used in city buildings when the city is ultimately torn down some time in the future.	●	• BedZED's local sourcing policy was able to source 52% of the materials from within the target 35 mile radius • In addition to that, 15% of the materials used were reclaimed or recycled	●	• The The IBA action plan concentrated on their strategy on saving the resources and making efficient use of materials, in order to create sustainable cycles. • On the other side, the using of intelligent building materials of the future is also the focus of the IBA's Hamburg projects.	●	The city uses locally appropriate principles of sustainable construction such as local materials, recycled materials, which can be used to pave the sidewalks, bridges and streets
8. Food System	●	• Masdar is going to be surrounded by a greenbelt featuring agricultural facilities and a variety of accessible green spaces, in which local agriculture is projected to supply a sizable quantity of Masdar's local markets. • Vertical farming will also be used, in which the fresh food will be grown in specially designed greenhouses.	●	At BedZED residents were encouraged to grow their own food in their sunspaces and on their roof gardens. Besides, there is a food-growing project, which will be established as part of the proposed adjacent ecology park.	●	The city encourages the sustainable food production and supply, in order to reach a concrete step toward sustainability.	●	El Gouna created a certified organic farm where they grow local organic products, as well as a fish farm that makes use of the rejected water from the desalinating units.
9. Energy Efficiency	●	The city will minimize energy demands by deploying the most energy efficient techniques available and that reduced demand will be met using renewable energy. New technologies, such as photovoltaics, concentrated solar power, geothermal and waste to energy, will supply 100 percent of the energy needs.	⊖	They made efforts to decrease the energy consumption and meet all the energy demand from on-site CHP but according to the technical problem CHP is not working now and need to be replaced, thus the energy efficiency system is not efficient	●	The city has a pilot concept which is the transformation of the fossil fuel into a solar, sustainable city that is ultimately able to source 100 per cent of its supply of renewable energy. To meet this concept, IBA created their spatial energy concept that can serve as a prototype for renewable Hamburg and set new standards for resource conservation within the existing buildings as well as the new ones.	⊖	Great efforts to conserve energy are implemented throughout the whole town. The city encourages the use of energy saving lamps and solar water heater and the energy saving cards at all hotels. The city planed to use a carbon-free energy supply system for the entire resort by using renewable energy sources, but according to the financial aspect there is a lack of the renewable energy sources and the energy distribution technologies.

Energy Consumption

Urban	**1. Orientation**	●	Masdar has been oriented north-east to south-west to provide an optimum balance of sun and shade.	●	Home and workspaces were best oriented north- south to gain the maximum privilege of the site conditions.	●	The IBA action plan encouraged the good orientation, in order to get the benefits of the sun and the wind, as well as achieve more energy benefits. Besides, future energy planning can contribute to a further increase in buildings' orientation, solar potentials in order to improve the buildings' exposure to daylighting, as well as helps to prevent undesirable wind currents.	●	EL Gouna is characteristics by its' sustainable and environmentally friendly layout. It has been taken into consideration that the majority of the buildings are well designed according to their site location, in order to get the best use of the privilege wind and the sun which are available at the site.
	2. Wind Direction	●	• The streets are mainly used for fresh air distribution and micro climate protection. • Buildings massing have been designed to make the most of fresh prevailing winds across the site, that by using the courtyards, or using stepping of the building mass, thus to create a wind corridor and increase the penetration of the air fresh between the buildings.	●	The majority of the buildings lay in the direction of the privileges wind, besides the design added active system inside the buildings to help the buildings to achieve certifiable ventilation and heat recovery performance.	●	• The concept depended on using intelligent building measures and wind barriers to make a major contribution in the open areas over long periods of time without compromising the access to fresh and cool air. • Besides, future planning can also contribute to a further decrease of the undesirable wind currents.	●	The buildings are well designed according to their site location, in order to get the best use of the privilege wind
	3. Solar Radiation	●	The design of the facade openings has adjusted respecting the high level of direct radiation on the project site. Also take in consideration that all the building should provide self-shading.	●	BedZED buildings were oriented for passive solar gain and employ high levels of thermal mass. They also used high super insulation to prevent overheating in summer and store warmth in winter	●	The IBA action plan served as a guideline for optimizing solar yield potential by differentiating in the building's height, in order to provide ideal conditions for the use of the buildings' facades and roof for renewable generation and thermal energy collection.	●	Comfortable indoor and outdoor spaces have been carefully sun protected and any surface exposed to direct sunshine have been well designed according to the sun orientation.
	4. The Exterior Environment	●	• All the exterior elements specify high recycled material and encouraging the reduction of embodied energy within materials used in the landscape elements • In addition to that, all the exterior urban surfaces are mainly depends on using high-albedo materials (light colors)	●	All earthworks for landscaping were done using on-site excavated materials such as the crushed concrete, which was used instead of fresh aggregate as road sub-base. Besides, the paving slabs were bedded in recycled crushed green glass which was used instead of virgin sand.	●	The action plan encouraged the using of white light colored in the surrounding environments, also encouraged the removal of the hard surfaces in the open spaces, as well as the using unpaved surface. This can be done in order to neutralize the urban heat island effect and improve the urban climate.	●	The majority of all the sidewalks are mainly used the high-albedo materials and the recycled waste materials, this will directly affect the indoor and outdoor thermal comfort and reduces the energy consumption within the district.
	5. Water Features	●	The project depends on using water features between the buildings in order to increase the cooling potential of a natural ventilation design strategy, also help in decreasing the outdoor temperature.	⊗	According to the master plan of the project, it was obvious that, there were no water features within the boundary of the site.	●	The IBA action plan strength the link between the water and the green areas, as well as encouraged the using of the water areas in order to increase the evaporating cooling effects and improve the urban climate in the same way	●	The city covers 10 km of beachfront and over 20 islands surrounded by artificial lagoons, besides the water features which used in the courtyards. This large amount of water takes up a large amount of heat in evaporation.
	6. Block Density	●	The city will feature density, low rise buildings with no more than five storeys, that to create compact districts with narrow streets.	●	The project chosen high build-density within a three-storey height restriction.	●	The IBA spatial energy concept promoted a lot of projects through planning techniques, in order to increase the density in the areas such as increasing utilization density in existing buildings, architectural consolidation,adding on.	●	The city's design is compact, high density features with low rise buildings from 3 to 4 storeys.

	7. Landscape	●	• Carefully planned landscape depend on local plants, which will aid in reducing ambient temperatures. • In addition to the, the Green parks which separate the built up areas, capturing and directing cool breezes throughout the city.	●	• The project mainly included over 4000 m^2 of green open spaces per Hectare. Besides, the project incorporated private roof garden for the units. The project also established an eco-park with an area 18-hectare of the adjacent site. • All landscaping elements made use of native plants.	●	The plan promoted the concept of enhancing the quality of the urban experience. This can be done by maintaining and upgrading open spaces, creating new landscapes and parks, as well as strengthening links between the water and the green areas.	●	• The landscaping options provide the minimum landscaping requirement to ensure that the community is as a lush green oasis in the midst of the desert. • They use native plant species for landscaping inside the courtyards to maximize cooling effect within the buildings.
	8. Exterior Block Properties	●	• The design of the project depends on using buildings with high-albedo materials. • The buildings' mass also help in minimizing adverse wind effects and optimize conditions for passive ventilation and cooling.	●	• The exterior material of the building envelope was well designed, as they used the solar sun space in the south to gain more solar radiation which was preferred according to their climatic conditions. • The buildings' mass has been designed in order to make the most of fresh prevailing winds across the buildings by using the wind cowl ventilation systems.	●	The IBA action plan encouraged the using of light colored light colored roofs and building material, in order to create an urban canvas of contrast for historical building, reducing the need for artificial light in urban spaces and buildings, also significantly reducing cooling requirements.	●	• The majority of all the buildings are mainly used high-albedo materials that will directly affect the indoor and outdoor thermal comfort. • The buildings' mass also help in minimizing adverse wind effects which directly minimize overall energy consumption.
Architecture	**1. Walls**	●	The façades were designed as multiple layers, the design depends on using the GRC panels in the first layer which are typically with thickness 25 to 30mm.	●	Buildings were constructed from heavy weight materials with high thermal inertia that can store heat during warm periods and radiate warmth during cooler periods.	●	• According to the IBA's spatial energy concept, all the existing building's facade will be renovated to enhance the energy requirement. • All the new buildings will be built according to the passive house techniques or to meet the requirement of the zero energy houses, thus all the technique properties for achieving well design building shell will be applied, such as the required u value, the suitable material. • Also, there is a new direction to use of intelligent building materials of the future. • Besides, the plan also promoted the concept of using green façade, as they reduce building's respectively to long wave radiation in summer.	●	The buildings are constructed with locally manufactured materials such as clay and natural stone with thickness from 50-60 cm, such building materials conserve energy and improve all environmental practices.
	2. Roof & Ceiling	●	The shape of the roof encourages the air flow, as well as the design depends on using circular openings in the roof of the balconies, so that the apartments can be naturally ventilated	●	Two types of roofs were used, the first was the high curved roof that has no regular access, while the second was the green roofs which planted with a low maintenance Sedum mat. Those green roofs consisted of a root resistant bitumen membrane laid on the concrete roof slab, then a polyethylene foil layer.	●	• All the existing building's roof will be renovated to enhance the energy requirement. On the other side, all the new building will meet the highest energy efficient technical facilities in the long run. • In addition to that, the strategy also promoted the concept of using green roofs, in order to improve the city's climate, preventing the urban heat islands and also increase the green space.	●	Buildings were covered by domes and vaults, in order to provide the interior with moderate climate.
	3. Daylighting Techniques	●	The design depended on using the high level clerestory and vertical slot windows in the walls, besides there are some buildings using the courtyards to increase the penetration of the daylighting.	●	The idea of the project in general is based on illuminating the buildings through roof lights. Those roof lights were triple glazed with aluminium frames.	●	The IBA plan encouraged the using of the daylighting techniques within the buildings, as well as optimized solar energy developments in order to increase the energy benefits and decrease the dependent on the artificial lighting.	⊗	The majority of the building didn't depend mainly on using daylighting techniques in their design. But on the other side, there are some buildings use some opening in the dome design to provide more daylight inside the building, but they represent a very small ratio compared to the whole buildings.
	4. Opening	●	The design depended on using a combination of solid aluminium glazing panels and timber framed windows.	●	All windows were either double or triple glazed. Timber frame windows were chosen over aluminium or UPVC for embodied energy and environmental impact reasons.	●	The renovation of the openings of the existing building is also within the renovation strategy for the IBA's spatial energy concept. As, these elements will be renovated to meet the energy requirement. Besides, all the new building will meet the highest energy efficient technical facilities by using effect windows.	●	The buildings depended in their design on the recesses, rounded shape windows, which were well designed according to the orientation. Besides, the east- west facing windows were limited in size in the buildings. Also, there were some buildings depended on their design on using the mashrbaia.
	5. Insulation	●	The design makes use of high level of insulation within a well-sealed inner façade.	●	All of the buildings were super insulated to provide useful heat gains in the winter. The high levels of insulation greatly reduced the heat losses through the building fabric.	●	• The action plan mainly depended on increasing the rate of the insulation technology for the facades, as it depend mainly on using standard solutions and specific materials to reach their goal for energy efficiency in the inexpensive way. •It aimed to reduce energy consumption by renovating of the existing buildings, also by developing new concepts of heavily insulated façade systems for all the new building.	⊗	The building's walls were constructed with locally manufactured materials with thickness from 50 cm to 60cm which used as insulation for the indoor. Thus, the design didn't need to add extra insulation, as the wall itself acts as insulation element.
	6. Shading Devices	●	• The buildings' form which depend on the using of the balcony spaces and vertical mashrabiya screens with its curved forms provide excellent shading. • The majority of buildings provided by self-shading system.	⊗	The project aimed to maximize heat gain from the sun in BedZED houses, also minimize solar gain in the north facing offices, in order to reduce the tendency to overheat and the need for air conditioning. The well designed master plan can effectively achieve this concept without the need to shading device in the design, as the design minimized the over shading by the adjacent buildings and the street below.	●	The IBA spatial energy concept also promotes the using of sunshade devices, in order to reduce energy consumption, as well as they depend on the vegetation in order to provide extra shading and enhance the urban climate	●	• The majority of the buildings used shading elements in different shapes to provide the shading on the building and improve the indoor and outdoor thermal comfort. • On the other side, the design of the buildings' forms used to provide shading on each other.
	7. Natural Ventilation	●	• The buildings designed around the courtyards which supporting the building's natural ventilation strategy • Besides, each apartment should maximize the cross ventilation within the unit, even if it doesn't depend on a court, they can use a solar chimney or any other techniques.	●	The project depended on using passive stack ventilation system. All BedZED buildings used the wind cowls which depend on the positive and the negative wind pressures, in order to deliver supply air and extract vitiated air.	●	The action plan optimized the good venation within the buildings, also promoted the using of ventilation ducts, in order to reduce the building's heat load, as well as increased energy benefits.	⊗	The buildings shape is compact with wide width, this means that the building shape is not efficient to provide cross ventilation. Also, the buildings' design didn't depend on using added techniques to enhance ventilation inside the building, such as solar chimney or wind cowls. But on the other side, there are some buildings depended on their design on the courtyards which somehow enhance the natural inside the building.

Energy Distribution									
	Smart Grid	●	The project provides smart utility grids which enable the using of renewable decentralized energy generation.	●	There is a communications technology network, which is a computer-based system, allows such functions as remote reading and billing of electricity, heat and water meters. The network cable routes were intended to be fully rewireable, so they can respond to future requirements.	⊗	It is planned to implement in the future an integrated energy network by smart use of innovative technologies in power supply facility engineering, in connection with building modernization and the integration of innovative control procedures for power grids, such as smart grids.	⊗	None- according to financial reason
	Smart Home	●	The project provides the smart home, which enable the using of integrated building automation technologies such as smart appliances.	●	The concept for BedZED centered on the idea of home energy autonomy and tried to influence residents energy use behavior by having the visible meters on the show	⊗	It is planned to implement the future building modernization technologies.	⊗	None- according to financial reason
Energy Generation									
Urban	**1. Off-site Biomass / Biogas plant**	●	They provide different projects to provide energy from waste, as Masdar City will work with the Abu Dhabi Municipality to develop such a plant to serve the Abu Dhabi metropolitan area.	⊗	They depended only on the on-site CHP plant, but nowadays great efforts should be made to find another solution to reach their zero carbon concept. In addition to that, extra recharging infrastructure off-site should be further advanced by the time to meet the demand of the electric vehicles instead of the panels integrated within the building shells. As, those panels become used for meeting the home electricity demand instead of the CHP plant.	⊗	No resources will be consumed from outside the IBA district area. As the main target is to meet the entire required energy demand from on-site sources. This can be done by adding more decentralized renewable energy productions within the area, in order to reduce ecological energy footprints.	⊗	None- according to financial reason
Urban	**2. Solar Farms**	⊖	There are a mix of international and UAE projects, such as Shams 1, 100MW CSP plant, Nour 1, Masdar PV, as well as Torresol Energy project. But, the panels around the site are proving less efficient than expected because of dust storms and haze, which can cut solar insulations by 30%.					⊗	None- according to financial reason
Urban	**3. Wind Farms**	●	There are mix of international and UAE projects, such as Sir Bani Yas Island, onshore wind farm, London Array–offshore wind farms, as well as Seychelles project.					●	The city achieves a reduction in the consumption of non-renewable resources by exploiting the wind power found in Hurghada, also using the wind turbine farms around the city.
Architecture	**1. Photovoltaic Systems**	⊖	Solar panels are integrated into the majority of the city's architecture and outdoor spaces, such as they can be used as canopies over the streets, shading element at the city center main plaza. Another will be mounted on the rooftops of the majority of the buildings, but some those panels on the roof of the showcase buildings were actually in the shade which means they produce significantly less energy.	●	BedZED's 10-year target is to produce enough electricity from photovoltaic panels to power 40 electric vehicles through using well integrated panels in the structure of south-facing facades of the buildings, but after the CHP stoped working they becomes using their energy to meet home electricity.	●	A special focus is promoting the using of the urban infrastructure and lands for solar energy, such as they can use the roof canopies over parking areas, bus stops and public squares. Also utilize building shell for photovoltaic units, thus no new buildings or energy renovation without consideration of photovoltaic technology, all the building should exploit every opportunity for producing energy through their own power generation such as using their facades and their roofs.	⊗	None- according to financial reason
Architecture	**2. Solar Water Heaters**	●	The project uses the solar water heaters as a source of renewable energy. Evacuated tube collectors will be roof mounted to provide domestic hot water.	⊗	None	●	The City' design deepened using the solar water heaters as a source of renewable energy.	⊗	The city encourages the concept of using of solar water heater at all the hotels and the homes.
Architecture	**3. Geothermal Heat Pump Systems**	●	Geothermal ground sourced heat pumps are planned to play a major role in cooling Masdar's buildings from the desert climate.	⊗	None	●	It is limited within IBA area due to the specific geological condition, thus there are only 3 homogenous distinguished drilling areas.	⊗	None
Architecture	**4. On-site Biomass / Biogas plant**	●	The City' design deepened on an on-site recycling plant which convert all of the waste into energy	⊖	BedZED receives power, heat and hot water from a small, locally placed CHP plant which is powered by off-cuts from tree waste. But, this is not currently in operation, according to main technical problems. Thus a great work has been done, in order to identify a replacement for this unit to maintain the commitment to a zero carbon development	●	The City' design deepened on an on-site recycling plant which convert all of the waste into energy.	⊗	None
Architecture	**5. On-site Wind Turbine**	●	• There are smaller urban wind turbines affixed to various buildings throughout the city. • In addition to the existence of the wind tower, which help in capturing the upper-level winds and direct them to the open-air public square at its base	⊗	None	●	Only large scale wind power stations are taken into consideration in the IBA area, small-scale wind power is discarded on the grounds of low efficiency and adverse urban environment impact. As an example the turbines used in the energy hill project	⊗	None
	Total points		32.5 points		24 points		29 points		20.5 points
Conclusion			Although critics have pointed out several major flaws with the sustainability of the city and its usefulness as a model for other cities, Masdar represent as a visionary project that will help develop green technologies such as the PRT system or the development of the solar and zero waste technologies		Although, all the measures of the consumption in the homes are much lower than the average current UK benchmarks, the residents living at BedZED are still unable to get to a one planet living level. As it is important that, the CHP plant should be replaced in order to achieve CO^2 development, also some public services need to be established around the site to reduce the daily transit.		Nowadays, Wilhelmsburg becomes an attractive residential neighborhood close to the inner city into which many key services have relocated. The various projects and concepts have been the key to the success of the IBA Hamburg. Also, the record of the consumption savings is also another reason, as by 2010, about 70% of the intended reduction was delivered this means that, it is possible to meet their reduction goals.		El Gouna city has succeeded to achieve the natural, cultural and technical images of sustainability. Besides, the project as a whole gives the many challenges to creating a truly sustainable tourist destination. Although the final project or the final outputs proved that the city can only be described as a good model for development, but not environmentally friendly according to the present of some deficiency points.

Table (4.1): Comparison between all the examples
Source: Adapted by the author

5. Chapter Five: Case Study

5.1. Introduction

5.2. The Analysis Goals

5.3. Analysis Methodology

5.4. Summary of the Existing Conditions

5.5. Observation on Al Rehab Case Study

5.6. The Specific Research Study Area

5.7. Conclusion

5.8. Comparison between the Existing Situation of the Selected Neighborhood within AL Rehab City and the Proposed Solutions to Maximize Energy Efficiency

5.1. <u>Introduction:</u>

This chapter aimed for analysis one of the Egyptian experience in constructing new settlements around Cairo. The chapter evaluated a selected case study, which is Al Rehab city, in order to analyze the evolution of the experience aiming to identify the positive and negative aspects and extract important outcomes. The chapter started with summarizing the existing condition of Al Rehab city, which represents an area housing a mix of middle and high-income groups. Then, it explored the concept of applying the design principles of sustainable neighborhood on the scale of the whole district. After that, it discussed the principles of configuration that are necessary to achieve the energy efficiency on a neighborhood scale. This leads the discussion to be on neighborhood 8 in Al Rehab City. This discussion has been set against the solutions which have been extracted from the literature review chapters and through the analyzing of the different examples. The main conclusion of this chapter showed that the selected case study did not meet most of the design principles from the environmental side. This is mainly meant that, there is a necessity to develop the design principles and update the current regulations to achieve energy efficiency in every new residential project.

5.2. <u>The Analysis Goals</u>:

The analysis aims is to evaluate the availability to create new residential neighborhoods with new urban environments that are more livable, organized and attractive. The main target is to apply the criteria of designing sustainable neighborhoods in order to reach a healthy life for everyone in Egypt while decreasing their effects on the environment and also in line with the country's economy. Hence, the research evaluates a selected case study, which is “Al Rehab city”. The case study has been selected according to its importance, as it represents one of the largest and successful communities in our country. Actually, it is widely agreed that, Al Rehab City is famous with its success as a role model in the social and economic aspect, while there is a little debate to know if it is succeeded from the environmental aspect or not. Hence, this part monitors the achievement of the environmental principles of a sustainable neighborhood through the design of Al Rehab, in order to be duplicated as a model in many of the future urban settlements.

5.3. Analysis Methodology:

To reach a concrete action, the analysis has tried to develop a model strategy for designing or redesigning neighborhoods to accelerate the opportunity to enhance sustainability in the residential built environment which fulfills the future energy requirements. As previously stated, the research outlines the main design principles for sustainable neighborhoods under different themes, with showing the complexity and interaction between those principles. Table (5.1) shows a comparison between two levels: the first one identifies the most important theories of the sustainable neighborhoods and sets their planning criteria, which have been extracted from the literature review chapter. The second level delineates the most common practical solutions which have been extracted from the analysis of the examples in the previous chapter, in order to set out the best actions, which can be applied to Al Rehab city. Then, the analysis has tried to apply those actions, which relate to the design principles of sustainable neighborhoods on the scale of the whole district, thus to be a form for the future vision of Egyptian sustainable neighborhoods that takes into account both the current circumstances and future challenges. On the other side, the principles of configuration that are necessary to achieve the energy efficiency have been discussed on the neighborhood scale, which is neighborhood 8 in Al Rehab City. Figure (5.1) shows an abstract of the analysis methodology.

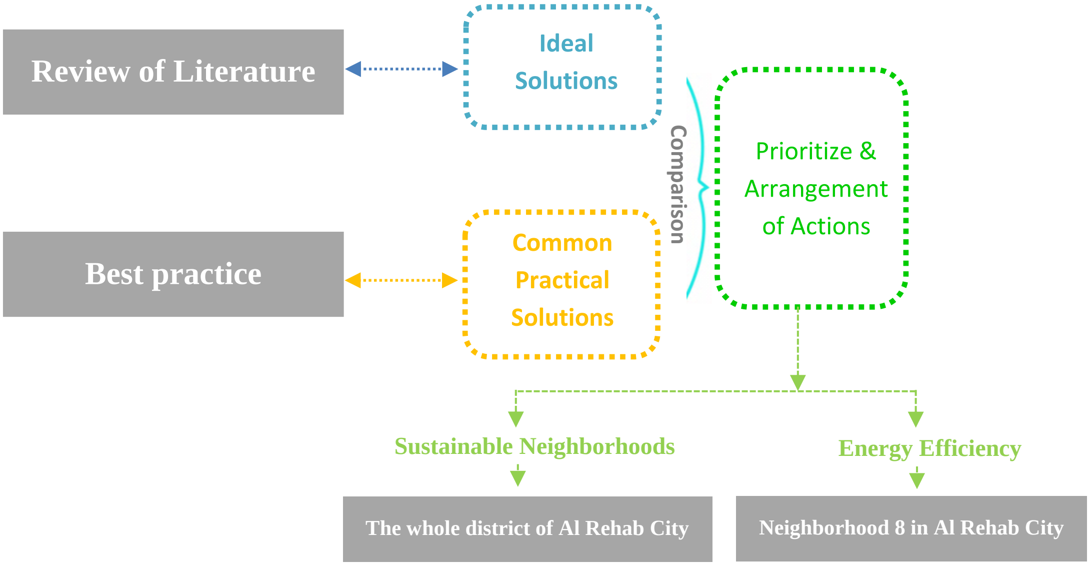


Figure (5.1): Abstract of the analytical methodology of the case study
Source: Adapted by the author

Design Principles	Theory	Indicators	Examples				Actions
			Masder	BedZed	Hamburg	El Gouna	
Vision as a sustainable development	The goal of sustainable development is to sustain human communities by development, which meets the present needs and improves the living conditions of people without neglecting and destroying the fundamental life systems and life chances of the future generations. Applying this definition would make the basic requirements of a sustainable neighborhood, self-sufficiency in food, water, energy and shelter: As the neighborhoods would have to be able to reproduce its population, be self-sufficient in terms of its own service requirements and to do all this while enhancing environmental quality without damaging its precious life support functions.	**Strong Strategy**	●	●	●	●	In order to ensure successful development of new neighborhoods in line with environmental principles a common vision of sustainability need to be defined in cooperation with all interested stakeholders and actors at the early stage of the project.
		Action plan	●	●	●	●	The Energy Action Plan should be set for any new development
		Rules	●	●	●	⊖	The development of a green energy policy represents one of the major characteristics of a sustainable district in order to reduce diverse environmental, economic and social impacts related to energy use.
		Assessment method / indicators	●	●	●	●	The project should follow any monitoring system such as a sustainability indicator or neighborhood sustainability certification, which can be depended on national or international rating systems such as the Green Pyramid, or LEED Neighborhood. Besides, the project should also meet the energy codes or standards in order to achieve energy efficiency within the neighborhood.
1. Land Use System	This refers to the efficient spatial arrangement of land uses in order to sustain human populations. Thus, in the sustainable neighborhoods, land can be used efficiently to accommodate the diverse places of dwelling, such as work, education and entertainment.	**Daily Destinations Proximity**	●	●	●	●	The project should be compact development which allows access to daily basic services within the preferred walking distance, thus to reduce the dependence on the automobile.
		Land Use Diversity	●	⊖	●	●	The project should provide a diversity of land uses and allow for integration of mixed uses on a neighborhood level. As it should integrate all aspects of city life, such as work, recreation, home, as well as the public services all in close proximity.
2. Waste Management	All sustainable neighborhoods should include an integrated waste management plan consisting of separate waste collection system, incentives for waste reduction and recycling, minimized building waste. They also can meet the annual energy demand by biogas energy produced from both dry urban and agricultural waste and converts it to energy.	**Reuse of organic waste**	●	●	●	⊖	1. The organic waste can be processed into composting facilities and then used as fertilizers for the landscaping.
		Recycling factories	●	●	●	⊖	2. Recycling on-site plant should be established near to your community or inside. That in order to save energy in transportation and reduce the volume of material to be processed by the government's waste contractors.
		Waste-to-energy	●	⊖	●	⊗	3. It's preferred to design the project around an on-site recycling plant, which converts all of the waste into energy.
		Garbage separation	●	●	●	●	4. Residents should have access for recycling containers, as well as separate garbage bins in which each bin is used for a specific material such as one for plastic bags, cloths and paper.
3. Mobility System	The sustainable neighborhoods should provide safe and affordable mode and route options for residents to move easily between dwellings and places of work. This should be done by using a green transportation network, which has fewer impacts on the environment. Therefore, it is absolutely necessary that a green transport plan is developed from an early stage of the project consisting of: public transport facilities (stops at walking distance), development of cycling and pedestrian paths, car pool systems, limited driving speed and parking spaces.	**Public Transport within a walking distance**	●	●	●	●	1. The project should allow access to different public transportation systems within a walking distance. In addition to that, efforts should also be done in order to make public transport more efficient and more attractive.
		Transit Proximity	●	●	●	●	2. The project should consist of a good mix of land uses connected with regional public mass transport systems such as the light rail, metro or public buses. All of this mix should be within the preferred walking distance which is a comfortable five minute from center to edge (a radius of approximately 400 meters).
		Intelligent Transportation Systems	●	●	●	⊗	2. The project should promote the concept of using electric vehicles and other innovative systems.
		Private vehicles	●	●	⊗	●	3. The private vehicles should be kept at the neighborhood's edge in a number of parking lots that will be linked by other mass transport systems such as the bus routes, in order to facilitate the transit within the neighborhoods.
		Pedestrian Route Connectivity	●	●	●	●	4. The project should focus on creating more attractive shaded sidewalks and pathways throughout the neighborhood in order to encourage walking. Also, the preferred pedestrian network should allow for optimal connections between the district centers and neighborhood sub-centers, as well as it should also be connected to with the non-motorized transport network.
		Car pool systems	⊗	●	●	⊗	5. The project can encourage the car pool displaces, which is four to five privately owned one vehicle, but this according to our culture can be hardly applied.

3. Mobility System		**Limited driving parking spaces.**	●	●	⊗	⊗	6. Decrease the spaces available for the parking areas within the boundaries of the neighborhoods to encourage the residents to use the public transportation.
		Cycling Network	●	●	●	●	7. The project should aim to make cycling more attractive, safer and more convenient, in order to make more people use bicycles than do so today.
4. Water Management	More sustainable neighborhoods should carefully manage consumption of potable water and treatment of wastewater to protect and restore the natural hydrology cycle, including aquatic ecosystems.	**Reuse Water On-Site**	●	●	●	●	1. All the waste water should be re-purified and recycled by the neighborhood's water treatment plant to be as grey water used to flush toilets in the household, as well as for irrigation purposes.
		Reduce Consumption	●	●	●	●	2. The project should apply a water cycle management plan, in which apply the reduction of water consumption. Thus, by promoting the using of water consuming appliances within the buildings such as dual flush toilets and pressure showers.
		Reduce potable water demand	●	●	●	●	3. The project should select the water supply systems and fixtures which can reduce the water demand.
		Use rain water	⊗	●	●	⊗	4. The project can implement efficient rainwater infiltration systems, in which rainwater can be collected from roof surfaces and stored in underground tanks for irrigation and toilet flushing.
5. Food System	This refers to the ability of providing a good access to secure, local food production. So any sustainable neighborhood should support local food production, also should reduce dependence on imported food, thus in order to reduce the amount of energy transportation used to distribute food.	**Local organic products**	●	●	●	●	The project should provide free allotment spaces, in which residents are encouraged to grow their own food and become able to get involved in greening process. In general, the project's resident can be involved in the greening roof process, as well as use the green corridors through the housing clusters, in order to form small urban farms which are easily minimized the convenience of growing fresh vegetables and fruit on site.
6. Housing	Sustainable neighborhoods should include an appropriate mix of housing types, sizes and density. As well as should also provide reasonable, adequate household for lower or middle income households. This affordable and diverse housing stock is critical to reach socially active places to live, as well as economically diverse society.	**Dwelling Diversity**	●	●	●	●	1. The project should include a range of building typologies which address diverse household types and sizes
		Housing Affordability	⊖	●	●	●	2. The planned population density within the project should support a range of household incomes.
7. Natural Systems	Sustainable neighborhoods should protect, enhance or restore habitat of sufficient quality and quantity to support locally significant plant and animal species. As it is widely known that, removing habitat has negative impacts on the balance of the natural systems.	**Natural Habitat Preserved, Restored, Enhanced or Created**	●	●	●	⊖	The project should preserve and restore the ecosystems which support the natural development of plant and animal populations. This can be done by creating a plan for the biodiversity conservation, which mainly depends on using the native plant species for landscaping, as well as promoting the idea of using green roofs and local frames.
8. Materials Conservation	Sustainable neighborhoods should promote the reuse and recycling of buildings and materials. In addition to the careful consideration for the source of the materials and their life-cycles. This means that, addressing environmental impact requires a whole-life approach, involving for any one material, its sourced from nature, its processing, transport, in-use by-products, recycling and reuse ability and avoiding its final waste disposal.	**Recycled Materials**	●	●	●	●	The project should support the concept of sourcing reclaimed and recycled materials where possible.
		Use materials from unconventional sources (low embodied energy)	●	●	●	●	The project should carefully select the materials with low environmental impact to be used in the construction phase. Thus the materials should be sourced locally where ever possible within a small range (e.g.35-mile radius) of the site where possible, to minimize the energy required for transportation.
9) Energy Efficiency	This mainly refers to the demand, supply and distribution of energy to power machines, buildings and vehicles. To reach more sustainable neighborhoods, energy demand should be reduced as well as increase opportunities to meet the demand with renewable energy and low emission sources. Also, efficient distribution systems should also be used such as community or district energy systems.	**Energy Consumption**	●	●	●	●	The buildings' design should reduce the energy demand by applying the passive design strategies.
		Energy Distribution	●	●	⊗	⊗	The project should consider smart grids, distribution management and end-user energy delivery in the early stages.
		Energy Generation	●	●	⊗	●	The project should support the concept of providing energy from renewable and low emissions sources

Energy Consumption

Urban	**1. Orientation**	The main layout concept should provide strategies for reduction of energy consumption by considering the climatic conditions of the site.	**Streets Layout** **Lots orientation** **Buildings Orientation**	●	●	●	●	The project should be designed according to the preferred orientation to gain the maximum benefit of the privileged wind and the sun. In this hot climate, the home should orient toward the east- west axis, so that its longest elevation is oriented toward the north and the south. In addition to that, the layout's streets should run east and west, while the lots should face the north or south.

Urban	**2. Wind Direction**	The main layout concept should support the concept of making the outdoor climate comfort and breezy, that can be done by oriented the buildings and the streets toward the prevailing wind.	**Buildings Orientation** **Staggered blocks**	●	●	●	●	The main layout concept should take care about the shading and ventilation strategy. The majority of the streets and distribution of building mass should be well deigned, in order to make the prevailing wind reach each block.
	3. Solar Radiation	The best designed house plan should respect the sun orientation, so that the surface which gains solar heat or solar radiation decreased.	**Street proportions** **Sun orientation**	●	●	●	●	The main layout concept should take care about the proper street proportions and the distance between the buildings in order to keep sunlight off of building walls. A good solar orientation should also provide solutions for the pedestrian to take the advantage of long shadows.
	4. The Exterior Environment	The exterior elements such as the walls, roofs, pavements, sidewalks, as well as the exposed surfaces of parking lots should be in light colors with low heat absorption coefficient, thus in order to lower the heat island effect.	**Light-colored (high albedo) surfaces** **Paving materials**	●	●	●	●	It is preferred to use the reflective paving materials instead of the impervious absorptive one such as using the white cement mixtures or light-colored pavers instead of traditional asphalt paving, so that the heat absorption and heat build-up can be reduced
	5. Water Features	The main layout concept should provide strategies for using water features such as sprinklers, fountains and lakes, so that they can provide evaporative cooling and increase the potential of natural ventilation	**Water Elements**	●	⊗	●	●	It is preferred to add large water bodies which blend into the landscape near the buildings and in the open spaces, thus to make outdoor areas breezy and causes significant cooling especially in a hot and dry climate.
	6. Block Density	Density standards in zoning districts targeted for sustainable neighborhood preferred to allow increased densities in locations to reduce the automobile dependence. Also the planned population density should support the feasibility of public transport, as well as provided shared infrastructure.	**High density**	●	●	●	●	The planned population density in the project should support the concept of high density compact urban form, in order to reach a district which is protected from solar radiation, reduced the dependence on automobiles.
	7. Landscape	Layout design uses the soft landscaping elements such as trees, shrubs and vines, to maximize the shading of streets and outdoor spaces for pedestrians, as well as to maximize the shading of the building envelope.	**Shading the house** **Outdoor areas**	●	●	●	●	The project's design should use the native plants and select the proper type of them, in order to maximize the shading of the building envelope. Besides, it is preferred to cover the ground with lawns or other ground covers rather than paving where possible to reduce sunlight reflected into the house and lower the surrounding ground temperatures.
	8. Exterior Block Properties	The building form determines the airflow pattern around the building, directly affecting its ventilation. Thus, to offer useful environment buildings should be spread out with large open spaces in between for unrestricted air movement.	**Bidding Form** **Building Size**	●	●	●	●	The project's should use the building mass configuration which is effectively appropriate to the context and climate. In this climate, the preferred building configuration is the linear mass which is seeking to minimize the corners and maximize the floor area in relation to the outside wall area.
Architecture	**1. Walls**	The buildings should be designed to make use of externally insulated, dense materials which has a higher thermal resistance, thus in order to decrease the energy required to heat and cool the building.	**Wall's Materials** **Wall's color** **Material's thermal resistance**	●	●	●	●	The project should aim to reduce energy consumption by renovating all of the existing building's shell and increasing the rate of the insulation for the walls, roofs, as well as windows. Also, great effort should be done in developing new concepts of heavily insulated façade systems for all the new building.
	2. Roof	The buildings should improve the thermal resistance of the roof's material, thus in order to decrease the absorption of the solar radiation. Thus the design should take into considerations the using of the cool roof systems, which are inherently reflective, light in color, as well as well insulated in order to achieve some of the highest reflectance and emittance measurements**.**	**Roof's material** **Roof' insulation** **Roof's form** **Cool roof systems**	●	●	●	●	The project should aim to reduce energy consumption by renovating all of the existing building's roof by increasing the rate of the insulation. Also, great effort should be done in developing new concepts of heavily insulated cool roof systems for all the new building.
	3. Daylighting	The building' design should promote the concept of using the daylighting strategies such as atrium, clear story openings, as well as solar tube, so that the daylight can penetrate deeply inside the building. Moreover, the design of the buildings should also promote the using of the proper buildings' mass and windows' dimension and location.	**Building's mass** **Window dimension / location** **Skylight strategies**	●	●	●	⊗	In the project, the passive design strategies which optimize natural daylighting access should be developed in line with climatic. As all the new buildings should be with narrow building shapes or they can be designed around the courtyard with a central open space, in order to penetrate the daylight deeply inside the building.
	4. Openings	The design of the openings should meet the requirement of the passive house standards which mainly depend on the specific ratio for the window to wall, U factor and the SHGC of the window, as well as the type of the glass and the windows, that in order to reduce the heat transfer while enhancing good visible light transfer**.**	**Window wall ratio** **Window type** **Glass type** **Openings place/ Dimensions**	●	●	●	●	The project should aim to reduce energy consumption by renovating all of the existing buildings' windows. In addition to the concept of using the proper window's location, size, type and insulation should be promoted within all the new buildings.
	5. Insulation	The buildings' shells which consist of the windows, roofs, as well as walls should be well insulated, in order to prevent energy waste as well as improve the indoor thermal comfort. In addition to that, the design should well select the proper type of the insulation material with the suitable R value, so that slow the rate of the heat transfers.	**Type of the insulation material** **Building's shell**	●	●	●	⊗	The project should aim to reduce energy consumption by renovating all of the existing building's shell and increasing the rate of the insulation for the walls, roofs, as well as windows. Also, great effort should be done in developing new concepts of heavily insulated systems for all the new building.

Architecture	6. Shading Device s	The buildings' design takes into consideration the using of shading devices for windows, so that it can create pleasant outdoor and indoor spaces. As all the buildings should use the proper direction, type and dimension of the shading devices. In addition to that, the shading devices should be added to the outdoor spaces in order to encourage walkability.	**Shading devices' direction** **Type of the shading devices** **The proper dimension**	●	⊗	●	●	In the project, more shading devices should be added to make outdoor areas breezy and reduce the indoor effect. Besides, the parking areas, the outdoor spaces and the pedestrian paths should use the landscape elements and the shading elements to decrease the outdoor temperature so that encourages the resident to walk.
	7. Natural Ventilation	The buildings should use the ventilation strategies such as the cross ventilation, the stack effect, as well as the wind catcher, so that they can reduce the cooling load. In addition to that, the placement and size of the openings should be designed according to the site climate and take the advantage of the privilege wind	**Window dimension / location** **Building's form** **Ventilation strategies**	●	●	●	⊗	In the project passive design strategies which optimize natural ventilation access should be developed in line with climatic. As all the new buildings should be with narrow building shapes or they can be designed around the courtyard with a central open space, in order to allow for increased natural ventilation inside the building as opposed to deep buildings.
Energy Distribution								
Urban	1. Smart Grid	Neighborhoods can promote efficient energy use, through efficient management of the distribution of energy. As the distribution of energy from the grid to the building or site will inevitably lead to some losses. So shifting to deliver energy in efficient way will help to reach an energy efficiency plan.	**Smart two-way communications network equipped with digital sensors.** **Integration of decentralized green energy sources**	●	●	⊗	⊗	The project should improve the existing transmission and distribution grids through the introduction of smart devices and a capillary communication network such as the smart grid. Those existing transmission and distribution grids should be redesigned to become two-way channel systems, in which they depend on electrical infrastructure that enable real time interactions among the devices, systems and operators. As well as, this electrical infrastructure should also allow the integration of distributed energy generation systems such as like wind, solar heat and geothermal heat, thus to decrease the dependence on the fossil fuel resources.
Architecture	2. Smart Home	Sustainable neighborhoods should depend on the term of smart or intelligent buildings, which depend on a computerized system. This system attempts the resident to choose the preferred settings that allow the smart appliances and equipment to turn off automatically when a large demand threatens, so that this is consequently helping to balance the energy load and preventing blackouts. Besides, its based on smart meters, which can operate digitally and allow controlling all the energy consuming operations in a building.	**Computerized Energy management system** **Smart meters** **Smart appliances**	●	●	⊗	⊗	All the buildings should use smart meters, they should be installed in place of the old, mechanical meter and these meters operate digitally and allow for automated and complex transfers of information between the home and the grid energy provider. Besides, all the building should use a computerized system that attempts the residents to choose the preferred settings, which allow the operation for specific smart appliances.
Energy Generation								
Off-site	1. Off-site Biomass / Biogas	At any sustainable neighborhood energy generation policies should include plans for electricity and heat generation through local renewable energy sources, in order to reduce their impacts on the environment. They are different forms of renewable energy sources which can be used off-site or can be represented as metropolitan sources such as the solar farms, the wind turbines, geothermal and biogas.		●	⊗	⊗	⊗	The project should promote the concept of generating energy from off-site renewable power generation as a source of energy to power the grid and the buildings instead the energy produced from the fossil fuel resources.
	2. Solar Farms			⊖	⊗	⊗	⊗	
	3. Wind Farms			●	⊗	⊗	●	
	5. Geothermal			●	⊗	⊗	⊗	
On-site	1. Photovoltaic systems	There are options of renewable energy sources, which can be used as on-site energy supply sources at any sustainable neighborhood. They can be used for power generation which allows a reduction in the amount of electricity that must be imported into the neighborhood through the community electric grid. Such reductions not only make the neighborhood more self-reliant and sustainable, but also extend the capacity and life of the community electric grid. It worthwhile to mention that, the most preferred applications of on-site renewable sources are the rooftop PV, the solar water heating, geothermal, as well as urban wind turbines.		⊖	●	●	⊗	The project should promote the concept of using the urban spaces and buildings' shells for the integration of the renewable energy, in order to produce energy which can be used within the buildings. 1. For the outdoor spaces they can use the roof canopies over parking areas, bus stops, as well as the public squares. 2. While for the building shell, all the buildings can exploit every opportunity for producing energy through their own power generation, such as integrating the photovoltaic units with their facades and their roofs.
	2. Solar water heaters			●	⊗	●	⊗	
	3. Geothermal System			●	⊗	●	⊗	
	4. Biomass / Biogas			●	⊖	●	⊗	
	5.On-site Wind Turbines			●	⊗	●	⊗	

Table (5.1): Shows a comparison between the most important theories of the sustainable neighborhoods and the most common practical solutions

Source: Adapted by the author

5.4. **Summary of the Existing Conditions:**

Al Rehab City is a fully-fledged community. It was the first city built by the private sector in Egypt having comprehensive services to cater for all needs of its residents. It was built-up in an area of 10 million m^2 in the New Cairo, in order to accommodate 200,000 inhabitants. It is located ten minutes away from Heliopolis and Nasr City and 20 minutes from downtown Cairo, at the intersection of the Eastern Ring Road with the Cairo/Suez Road. Its site is well connected with the surrounding city level, as shown in figure (5.2). It is also worth mentioning that, the location lies on the North East side of the New Cairo, as it lies between two other new satellite cities, namely Al Benfsj and Northern Investors (Al Rehab City, 2011).

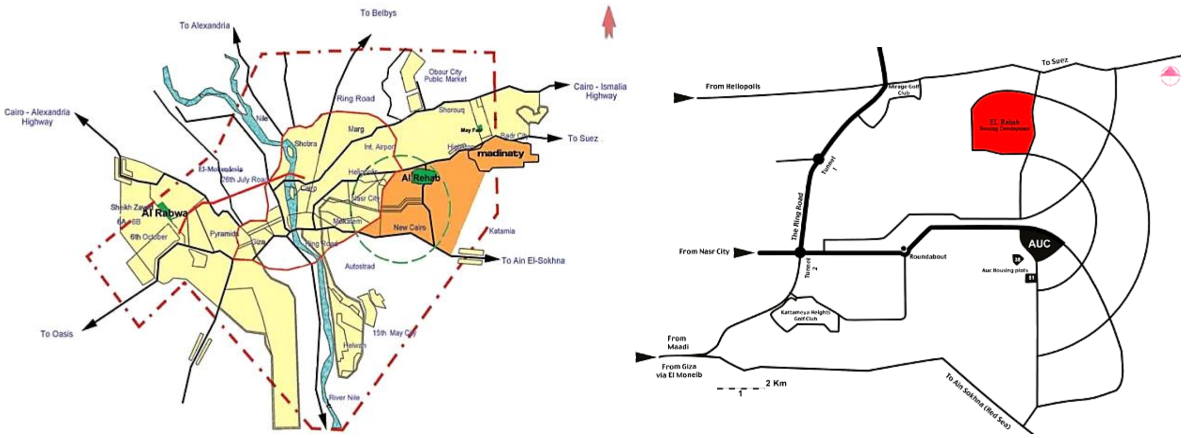


Figure (5.2): Location of Al Rehab City
Source: (Al Rehab City, 2011)

The construction of "Al Rehab City" was scheduled in six phases and was later extended to become ten phases upon its completion, each one was built on an area of 240 feddans, as show figure (5.3). It contains residential compounds, houses, villas and world class five star Hotels and golf courses. Besides, all the services needed are provided throughout the city, including a variety of facilities such as schools, banks, markets and malls. It's worthwhile to mention that, it is supposed to offer home in the districts 1-6 to about 120 000 inhabitants, in addition to other 80 000 inhabitants are expected to find a place to live in the districts 7-10. (Yousry, 2009).

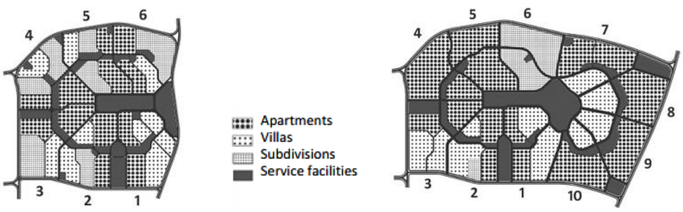


Figure (5.3): Phases of Al Rehab City
Source: (Yousry, 2009)

On another perspective, it's worth mentioning that, the district of Al Rehab is aiming to accommodate middle income and high-middle income groups. For that reason, the apartment’s sizes range from 60 $m^2$to 320 m^2 with a majority of medium sized flats that range from 120-150 m^2. It also offers 52 different prototypes for five story walk-up building apartments in the development phases. All apartment building areas are designed in groups, where clusters of the apartment buildings enclose green open spaces, interconnected together by a pedestrian network, which is totally separated from the vehicles roads and parking lots. It also includes different types of villas including attached, semi-attached and detached villas with a majority of the attached and semi-attached types. Villa prototypes have reached 26 and range from 170 square meters, semi-detached villas to 520 square meters luxurious one (Yousry, 2009).

5.5. Observation on Al Rehab Case Study:

The analysis is based on comparing between the designing of the Al Rehab City against the design principles of the sustainable neighborhood, which are complex and contradict to each other. It is also worth mentioning that, the analysis aims to outline a criteria system for Egyptian Sustainable Neighborhoods, in which the neighborhoods could become fully sustainable with a minimum reduction in the environmental impact.

5.5.1. Waste Management:

The literature review mentioned that, the sustainable neighborhood should include an integrated waste management plan which consisting of separate waste collection system, incentives for waste reduction and recycling building waste (McGeough et al., 2004). In Al Rehab City, it was mentioned in the study done by Yousry (2009) that, there is a system for garbage collection in the city, but actually, it is not a fully integrated waste system. Accordingly, there are different solutions and techniques can be used in Al Rehab City in order to upgrade its waste system. It is recommended to use the organic waste as fertilizers for the gardens and the landscaping. Also, separation systems for waste can be applied, for example the separation waste system at El Gouna City, as there are different bins each one is used for a specific material. Besides the recycling plant should be established near to the community or inside, so the garbage and solid waste can arrive easily and daily at the plant. To sum up, it can be said that the waste system in Al Rehab City needs to be improved in the long run, in order to become an integrated waste management plan.

5.5.2. **Land-Use System:**

It is stated by Bodenschatz et al. (2008) that, more sustainable neighborhoods should use land efficiently to accommodate the diverse places of dwelling, work, education and play vital to sustaining human populations. Also, the study by Kim (1998) demonstrated that, it should give its residents the ability to apply to their daily needs within walking distance. In the case study, it is widely known that, it has always been distinguished than the other gated communities with its services, running from day one of operation. It’s worthwhile to mention that, it has own its mixed use areas, which have a variety of services and facilities such as daily markets, banks, restaurant, schools, parks and recreation areas in proximity of residential buildings. Figure (5.4) shows the diversity of land uses and different facilities within the area. Those facilities and services add to the attractiveness of the area and reduce the energy needed for commuting to meet the basic and daily services. This means that this theme is positive and is probably exist in Al Rehab neighborhood design.

Figure (5.4): Al Rehab land-use plan
Source: (Al Rehab City, 2011)

5.5.3. **Mobility System:**

It is worth mentioning that, the project is provided by an internal public transportation network. This network consists from an internal shuttle bus system, in addition to the buses that transport the visitors and employments from outside central areas in Nasr City and Heliopolis districts. This internal public transportation network has always been distinguished Al Rehab district than the other communities. The district provided only three lines of public buses to serve the whole district, as well as provided stations for them, as shown in figure (5.5) (Yousry, 2009). It's worth mention that, only three lines are not enough to cover the whole area of Al Rehab, this consequently makes the internal circulation of the residents depends mainly on their private cars. According to that, it is preferred to increase the bus stations in the neighborhood with a maximum distance 400m from any public transportation station, in order to be in close proximity to the residential buildings. As described previously in the study done by Kellett et al. (2009) that, the preferred walking distance should be a comfortable five minutes walk, which approximately represents 400m. Subsequently, this means that each neighborhood should have two bus stations to cover the required walking distance, as proposed in the figure (5.6). This is essential to be improved by the time in order to increase the dependence of the residents on the public transportation.

Figure (5.5): Public buses
Source: (Al Rehab City, 2011)

Figure (5.6): Hierarchy of roads within Al Rehab
Source: (Al Rehab City, 2011) adapted by the author

To sum up, it can be said that, there is a real challenge in determining the best way to reduce carbon emissions from residents in the neighborhood. The residents should reduce their reliance on a single vehicle, as well as a shift from private to public and non-motorized transport for daily commuters in order to reach cleaner environment. Accordingly, different solutions and techniques which are extracted from the literature and the examples, can be proposed to improve the neighborhood's circulation network like:

1) Improvement of the quality of the infrastructure, in order to make the public transport more efficient, more attractive and lower-emission. So better connections between neighborhood shuttle services and public transportation could encourage residents to arrive and depart via public transportation. Those alternative public transportation systems should be safe, affordable, flexible, as well as reduce emissions and noise pollution. In addition to that, they should be well connected and available within the preferred walking distance which is the 400m from any public transportation station, as shown in figure (5.7).

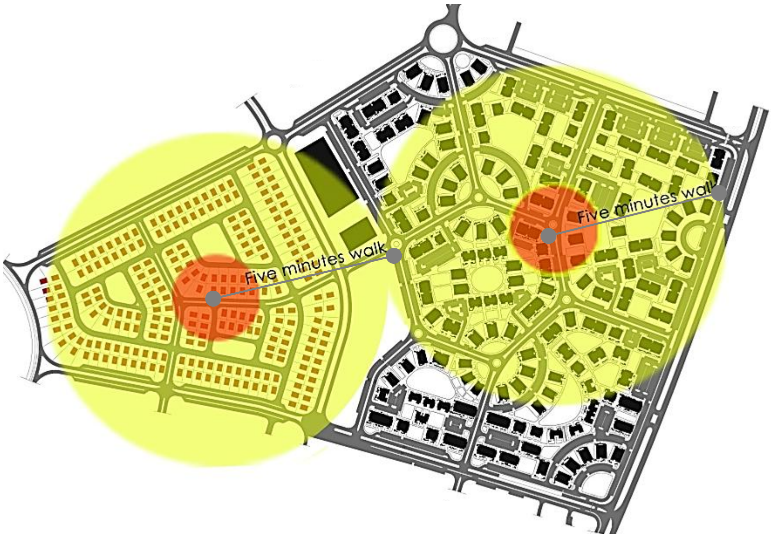


Figure (5.7): Walking distance within neighborhood 8 in Al Rehab
Source: (Talaat Moustafa Group, 2013) adapted by Author

2) Promotion of a number of electric vehicles and other innovative systems, which can be used as a type of new intelligent transportation systems which can help in reaching healthy environment, as well as reduce emissions.

3) The private vehicles should not be allowed inside the neighborhoods. In addition to that, large vehicle parking areas should be provided at the edges of each neighborhood. Furthermore, a good access to bus, tram stops and all other transportation services should be possible by walking or cycling. In the case of Al Rehab City, it was observed that, the design of the parking areas covers a large area of the neighborhood design. Those parking areas are classified into two types: the first one is the parking lanes along the two sides of the streets, while the second is the parking spaces in front of the residential blocks. For example, figure (5.8) shows the forms of the parking areas in the neighborhood 8 in Al Rehab. Those car parking areas are raising the temperature of outdoor spaces and have some negative impacts on energy consumption. Hence, it is

recommended to free the residential areas from cars by locating car parking on the edges of the project like in Masdar city, as shown in figure (5.8). Thus to encourage the visitors and the residents to use the public transportation network inside the neighborhood.

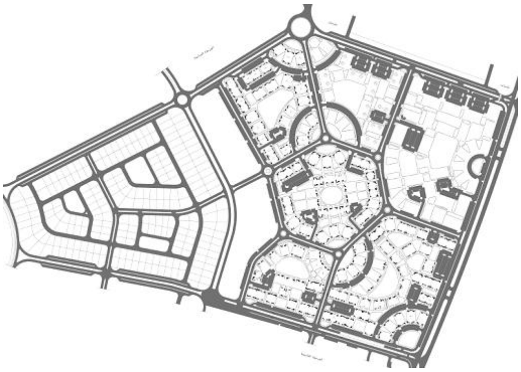


Figure (5.8): Forms of car parking areas within neighborhoods 8 in Al Rehab
Source: (Talaat Moustafa Group, 2013) adapted by the author

Figure(5.9): Proposed parking areas
Source: (Al Rehab City, 2011) adapted by the author

4) According to the design of the internal movement network of Al Rehab, all the streets are dominated mostly by car lanes and do not have enough shading instruments to cover the pedestrian paths nor cycle lanes to encourage cycling, as shown in figure (5.10). That's make the cars' usage the most convenient ways to commute through the area, which have negative impacts on the environment. The main aim is making the soft transportation such as walking and cycling more attractive, safer and more convenient, in order to persuade more people to them than they do so today. Hence, the design proposes to redesign the streets and provide them with cyclist lanes, as well as shading instruments to encourage the residents to walk, as shown in figure (5.11).

Figure (5.10): Example of section of existing street within AL Rehab City
Source: (Talaat Moustafa Group, 2013)

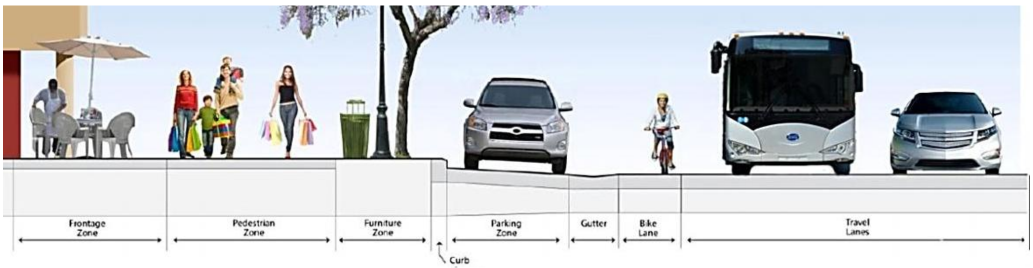


Figure (5.11): Example of the preferred street
Source: (Broward Metropolitan Planning Organization, 2011)

5.5.4. Water Management:

The sustainable neighborhood should include a complete water management plan, which consist of: treatment of waste water and implementation of efficient rainwater infiltration systems. The plan should also reduce water consumption by using water saving devices (Colorado, 2009). This complete water management plan is not available in Al Rehab district, so there is a highly need to establish this plan. As, the design of al Rehab city only use wastewater in irrigation in some neighborhoods, but it cannot be represent a complete water mangment plan. Thus, it is recommended to start with using the water-efficient fixtures, which can be used inside the buildings to reduce water demand. Then the waste water could be reused, in order to produce clean or reusable water in the building. For example, figure (5.12) shows the grey water system which can be used to reuse the waste water in flush toilets and irrigate gardens. To sum up, it can be said that the complet water system in Al Rehab needs to be improved in the long run, in order to decrease the rate of consumption of the water.

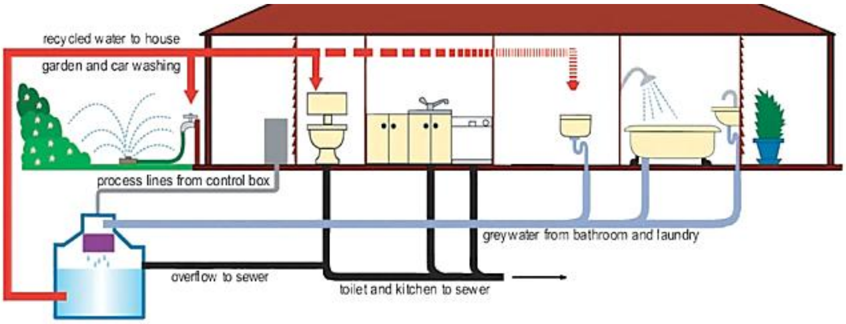


Figure (5.12): Example of Grey water system
Source: (The Environment Writer, 2011)

5.5.5. Food System:

As mentioned in the literature review that, the sustainable food system refers to the good access to the secure local food productions. So it is important to note that the neighborhood should reduce dependence on imported food, also should support local food production in order to reduce the amount of transportation, energy used to distribute food (Kellett et al., 2009). It is worth mentioning that, this factor does not exist in the neighborhood. Thus, it is recommended to use the green corridors through the housing clusters, in order to provide on-site food production in Al Rehab, as shown in figure (5.13). This will help to form small urban farms which are easily accessible and maximizing the convenience of growing fresh vegetables and fruit on-site from the edible public landscape planting. From the other side, the residents can also involve in the greening roof process. This green infrastructure network, such as green roofs, green streets and adequate vegetation cover, can reduce the heat island effects and adds productive land areas that are lost by developments.

Figure (5.13): Example of small urban farms through housing clusters
Source: (Zedfactory, 2014)

5.5.6. <u>Materials Conservation:</u>

As previously mentioned in the study by Kellett (2009) that, the environmental impacts require a whole-life approach for any material. This means that; the sources of materials should be carefully considered, as it should be sourced from nature. Besides, their life-cycles also should be carefully considered like: its processing, transport, recycling and reuse ability and finally avoiding its final waste disposal. The study also argued that, whenever possible the sustainable neighborhood should be built from natural, recycled or reclaimed materials. In the context of the Al Rehab City, using recycled materials is not exit, so the first step should be by using separating waste bins that will make the separation system of the garbage easy. After that, establish a recycling plant near the community to make the process of the recycling easy and quickly, in order to decrease the need of transporting for a long distance.

5.5.7. <u>Housing:</u>

Sustainable neighborhoods should include an appropriate mix of housing types, sizes and density, resulting in diverse, safe and socially active places to live (Kellett et al., 2009). In Al Rehab district the design mainly contains a variety of housing units, as it includes villas and apartment buildings. It is worth mentioning that, the development of Al Rehab aimed to accommodate middle and high-middle income groups. As, it offers 52 different prototypes for five story building apartments, as well as there are 26 villa prototypes, including attached, semi-attached and detached villas. All of the villas' size ranges from 170 square meters to 520 square meters in the luxurious ones with private gardens taking up at least 60% of the total plot area (Al Rehab City, 2011). While on the other side, there is a lack of planning for affordable housing to promote equity suggest. This means that; this factor is not efficient enough, as the design provide the mix of the housing types, but with no affordable for low income, which have indirect impacts on the environment.

4.5.8. <u>Natural Systems:</u>

This refers to the network of places, ecosystems that support the natural development of the natural system within the neighborhood (Kellett et al., 2009). It also stated by McGeough et al. (2004) that, all sustainable urban design must begin with a thorough comprehension of the immediate physical environment and the natural forces that shape it. In the context of the Al Rehab City, this may be appeared in the green infrastructure network which mainly depends on using the native plant species for the green network used in the streets, besides the adequate vegetation covers and the landscaping services for both public open spaces and private gardens (Yousry, 2009). These services reduce the heat island effects and adds productive land areas that are lost by developments. Accordingly, this factor has an affective effect in the design of the Al Rehab neighborhood.

5.5.9. <u>Energy Efficiency:</u>

Like many other places in the world, the decoupling of energy growth in Egypt will be one of the important factors in the future. The whole nation has to work hard for improving energy efficiency and increasing economic productivity. It’s worth mentioning that, the challenges are to secure energy resources and production, which are important for meeting the national demand both on the short and long terms (UN-HABITAT & UNEP, 2009). In the study done by Georgy & Soliman (2007) showed that, to face these challenges, Egypt should adopt different measures to increase the role of rational use of energy (RUE) and renewable energy (RE) in the energy supply. The study also argued that, Egypt is still in the development phase of legislation supporting the use of renewable energy, although it has varieties of renewable energy resources such as solar, wind and biomass. These resources are generally not yet exploited on a commercial scale except for wind energy, they currently represent only 1 % of the energy mix. Hence, the study recommended that, the policies of the present day should be aimed for localizing the renewable energy supply chain and strengthening technological capabilities at various levels. Furthermore, it is also recommended that, to use the untapped potentials exists in utilizing the renewable resources to generate electricity instead of the fossil fuels, those potentials are like:

- Egypt has one of the highest levels of solar irradiance in the world, as it is located in the "Sunbelt region".
- From the other side, the coasts of the Mediterranean Sea and of the Red Sea, present one of the strongest wind resources worldwide which can be used.

Methodology: Towards Energy Efficiency:

There are several steps should be followed to achieve the energy efficiency in Al Rehab. The first step should be through applying passive design strategies which will reduce primary energy consumption like: adding some external shading devices to decrease the impact of the solar radiation, also renovating some elements from the building envelope shell like windows, wall and add extra insulation. These methods can help in decreasing some of the heat lose inside the buildings, which decrease the energy consumption rate at the neighborhood scale. Then, the second step can be done by optimizing the distribution grid systems, which will allow a further saving. Additionally, optimize the building performance by using the smart building management techniques. Finally, using renewable energy sources and actively renewable strategies to reduce the primary energy demand. The study done by UN-HABITAT & UNEP (2009) explained that, this is the most expensive, while offering the lowest relative environment impact returns. The study also argued that, the designers should first concentrate on applying passive design strategies, thereby reducing the large amounts of energy demand with little cost and not only subsequently looked at what active controls could be implemented.

5.6. The Specific Research Study Area:

The energy efficiency configurations have been discussed on a neighborhood scale, which is neighborhood 8 in Al Rehab City, as shown in figure (5.14). Figure (5.15) shows the layout of neighborhood 8 in Al Rehab City. This discussion has been set against the design principles of the energy efficiency, which have been extracted from the literature review chapter. Its also based on an observation during a site visit.

Besides, the using of simulation software for environmental design (Vasari) to analysis the simulated design options and their ability to provide a crosscheck of the simulation results. This determines the combinations of measures that minimize energy use for the study area. In general, the discussion has based on the environmental aspects which relates to energy efficiency without concentration on socioeconomic aspects.

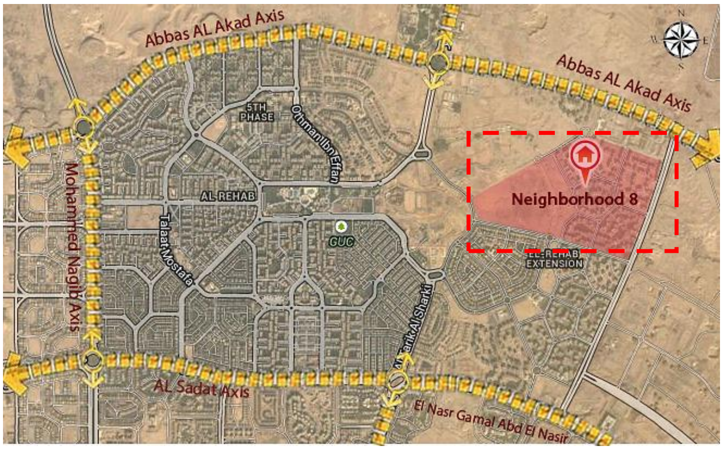


Figure (5.14): Location of Neighborhood 8 in Al Rehab City
Source: (Google, 2013) adapted by the Author

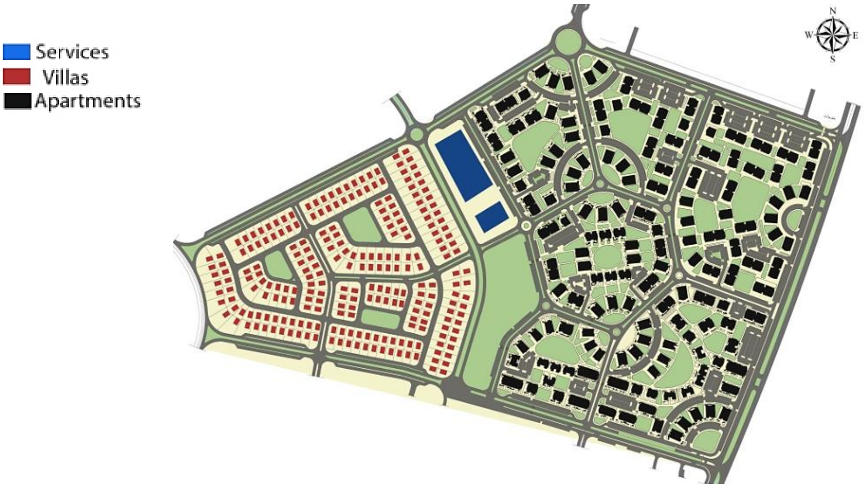


Figure (5.15):Layout of Neighborhood 8 in Al Rehab City
Source: (Talaat Moustafa Group, 2013) adapted by the author

5.6.1. Energy Consumption:

5.6.1.1. Urban Scale:

For an optimal fulfilment of these analyzes, local conditions and site analysis must be determined while analyzing the planning solutions. The site analysis holds many aspects related to energy efficiency and consumption like: climate and wind direction, as show figure (5.16). In the context of Al Rehab, the site has elevated level, which rises 60 meters over the Muqatam Heights. The high elevation of the location allows more winds to penetrate through the area which accordingly enhances the ambient temperature. Conversely, Al Rehab City is characterized by its unpolluted air and all-year round moderate climate. It is worth mentioning that, the planners and developers of the project surrounded the compound by a wide green belt of lush greenery, in order to preserve it from the undesirable wind (Talaat Moustafa Group, 2013).

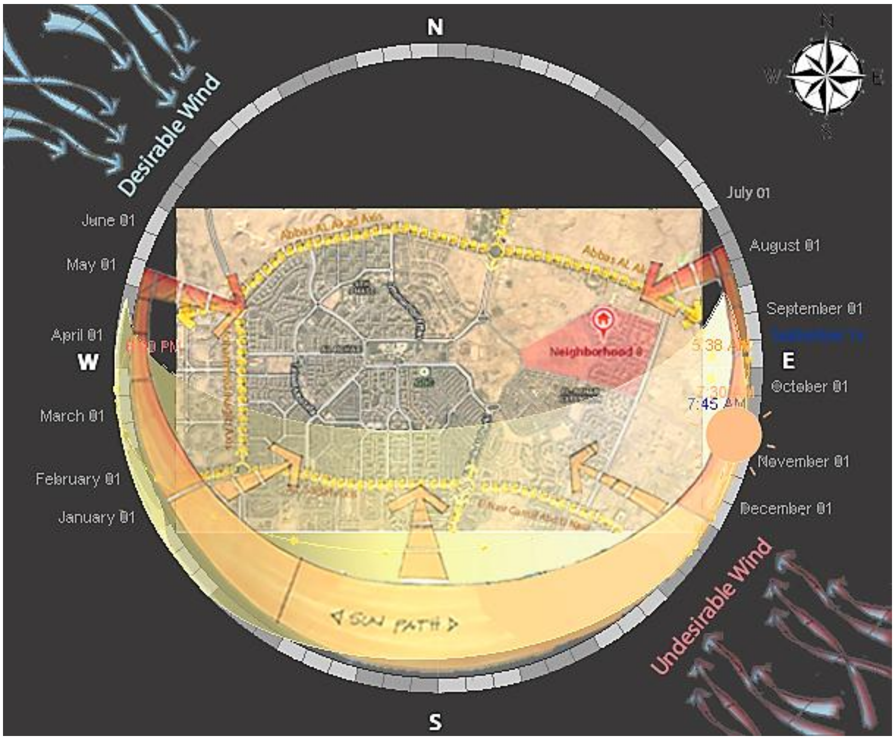


Figure (5.16): Site analysis of Al Rehab City
Source: (Analyzed by Vasari program) adapted by the Author

I. <u>Orientation:</u> As mentioned in the literature review, building orientation should be corrected in the direction of wind and sun. Orienting the buildings along the east-west axis is the preferred one, so that its longest elevation is oriented towards the north and the south. In addition to that, the layout's streets should be oriented northwest-southeast in order to gain the maximum benefit of the desirable wind (Leona, 2005). In the case study the design did not take the maximum advantage of the site conditions, as it did not pay attention to the ideal orientation, which led to decrease in the efficiency of the buildings. Figure (5.17) shows that the majority of the buildings were oriented with an angle of 45 degrees to the prevailing wind, which represents the least effective orientation for a building from a thermal efficiency point of view. The figure also shows that, the urban pattern results in a high exposure of solar incidence, which heats up the surfaces of the buildings and pedestrian paths. In addition to that, the urban pattern also were not allowed the desirable wind to penetrate between buildings, as shown in figure (5.18).

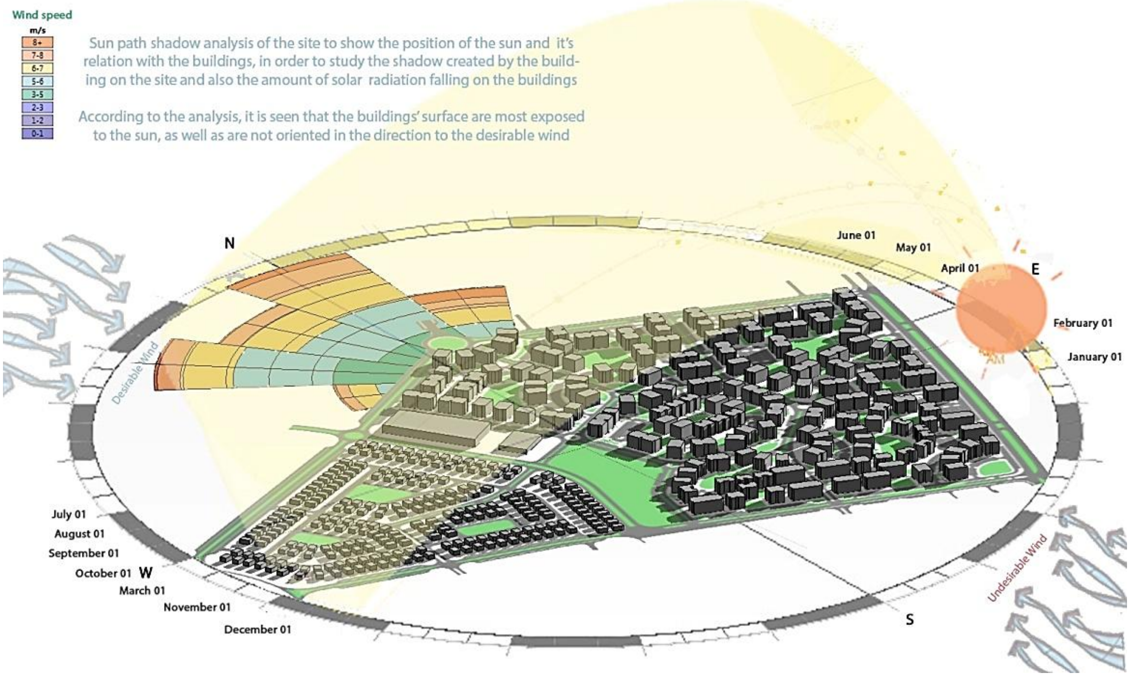


Figure (5.17): Sun path shadow analysis and wind direction analysis
Source: (Analyzed by Vasari program) adapted by the Author

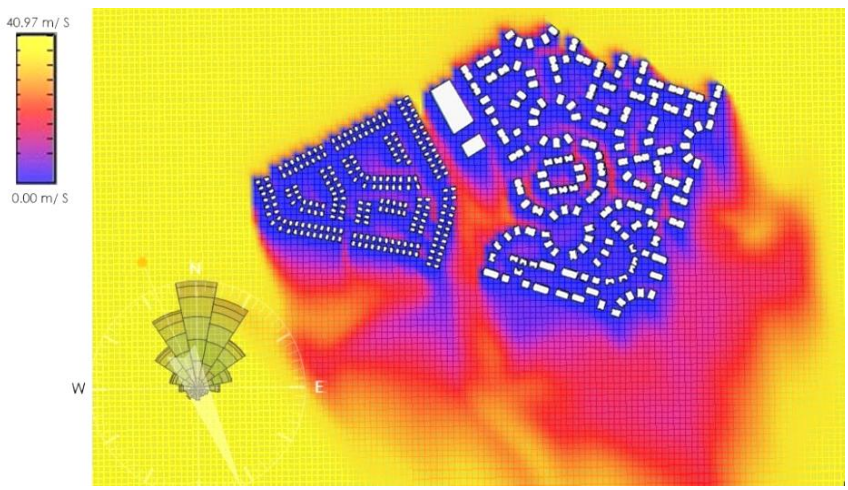


Figure (5.18): Shows the wind shadow analysis
Source: Analyzed by Vasari program

In addition to that, the design of the building prototypes is not efficient in its relation to the site conditions. As it is apparent that, almost the same prototype is oriented in a different orientation, which make the design of the prototype is not efficient in some directions, as shown in figure (5.19).

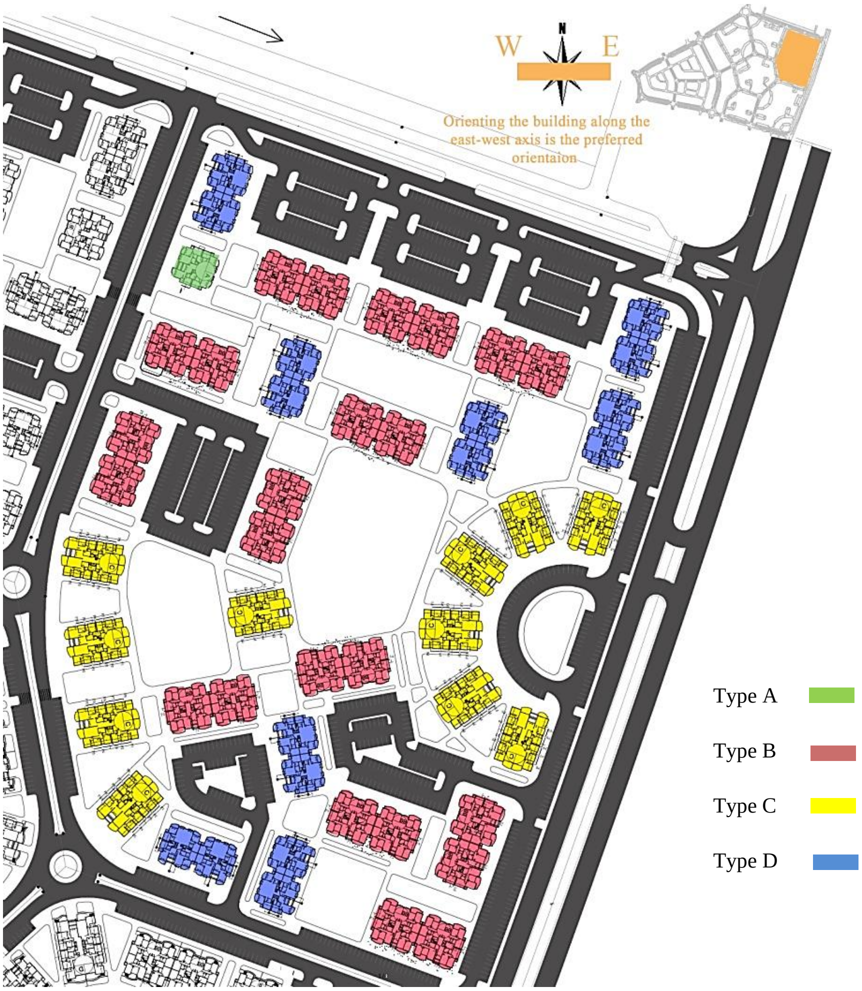


Figure (5.19): Example shows that the same prototypes used in different orientations
Source: (Talaat Moustafa Group, 2013) adapted by the author

II. Wind Direction: The main layout concept should consider cooling and ventilation of public space and built fabric, therefore the street orientation needs to accommodate inbound winds, which reduce heat gain and encourage natural ventilation. Hence, the majority of the streets and distribution of building mass should be well deigned, in order to make the desirable wind reach each block. In addition to that, the building distribution should not obstruct the desirable winds to provide ventilation for outdoor spaces. (Leona, 2005). According to the site analysis, the desirable winds are coming from the NW direction which results in a northwest axis, as shown in figure (5.20). In the case study, the majority of the main streets in the villas zone were oriented to gain the maximum advantage of the desirable wind. While the main streets in the apartments zone were not well oriented to gain the advantage of the desirable wind. Figure (5.21) shows that the main streets indicated by the red arrows, which should be oriented along the main wind direction.

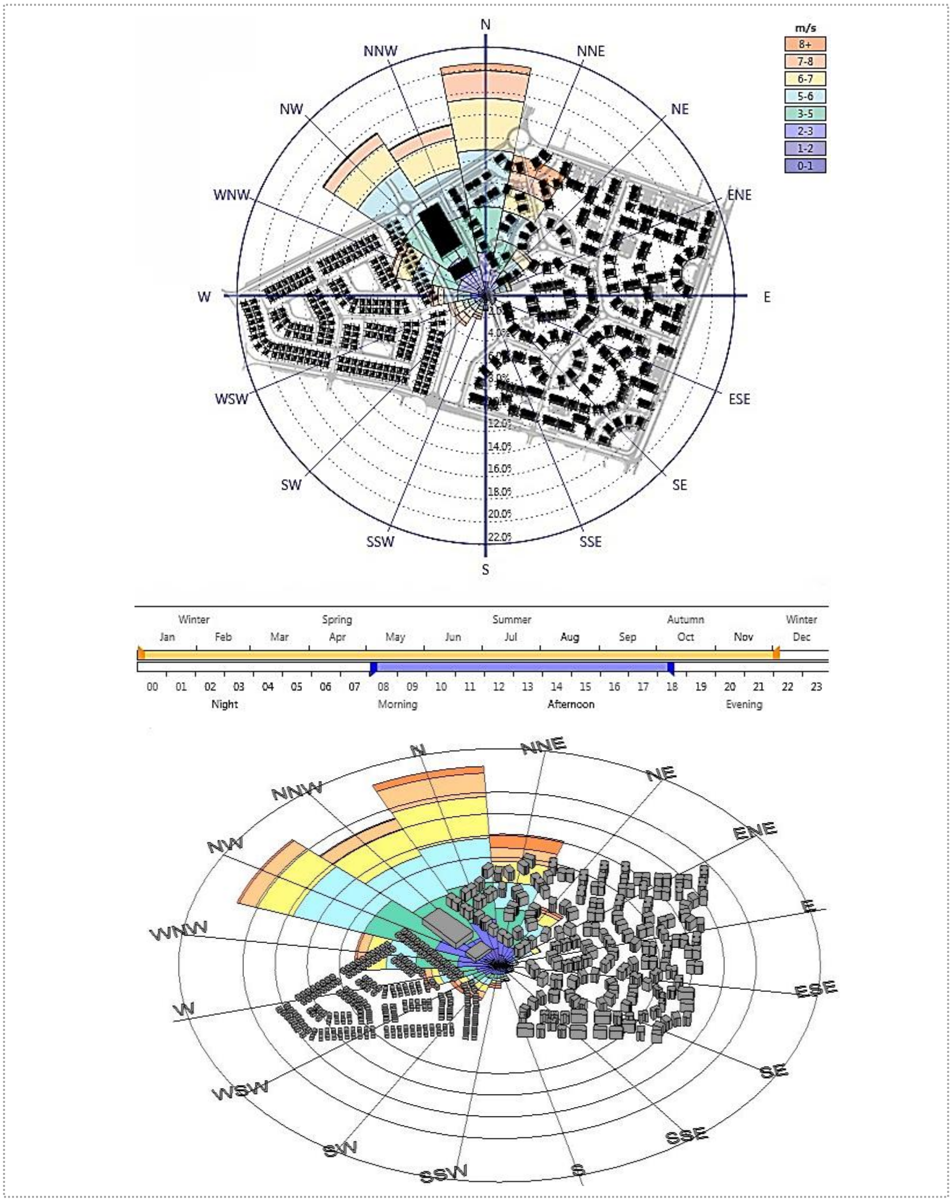


Figure (5.20): Wind analysis in order to give the direction of the prevailing winds
Source: Analyzed by Vasari program

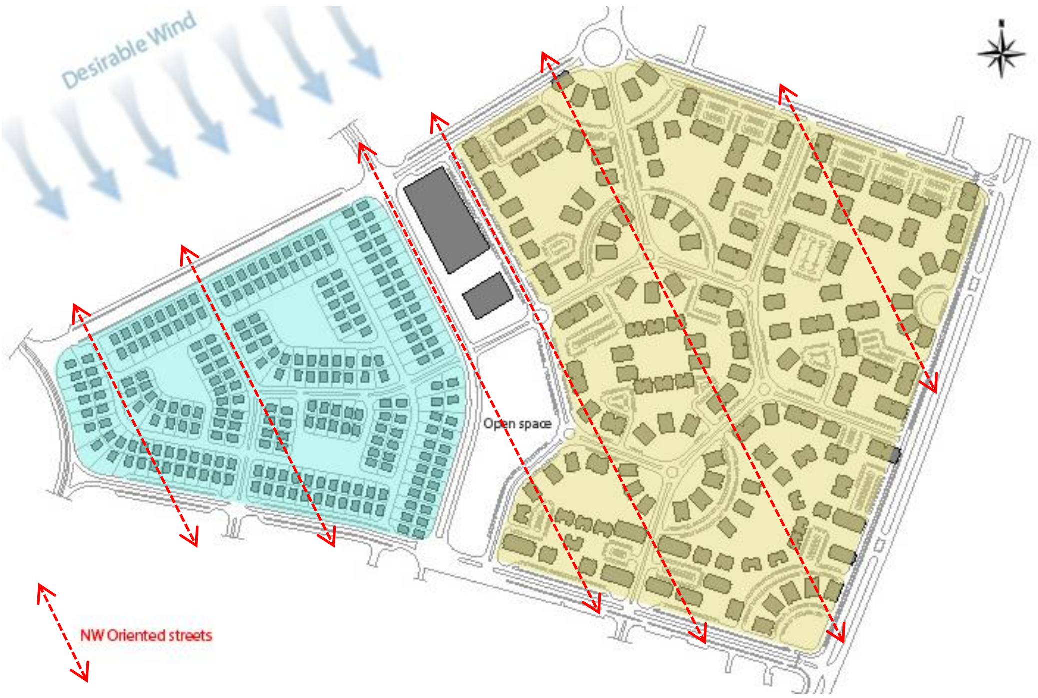
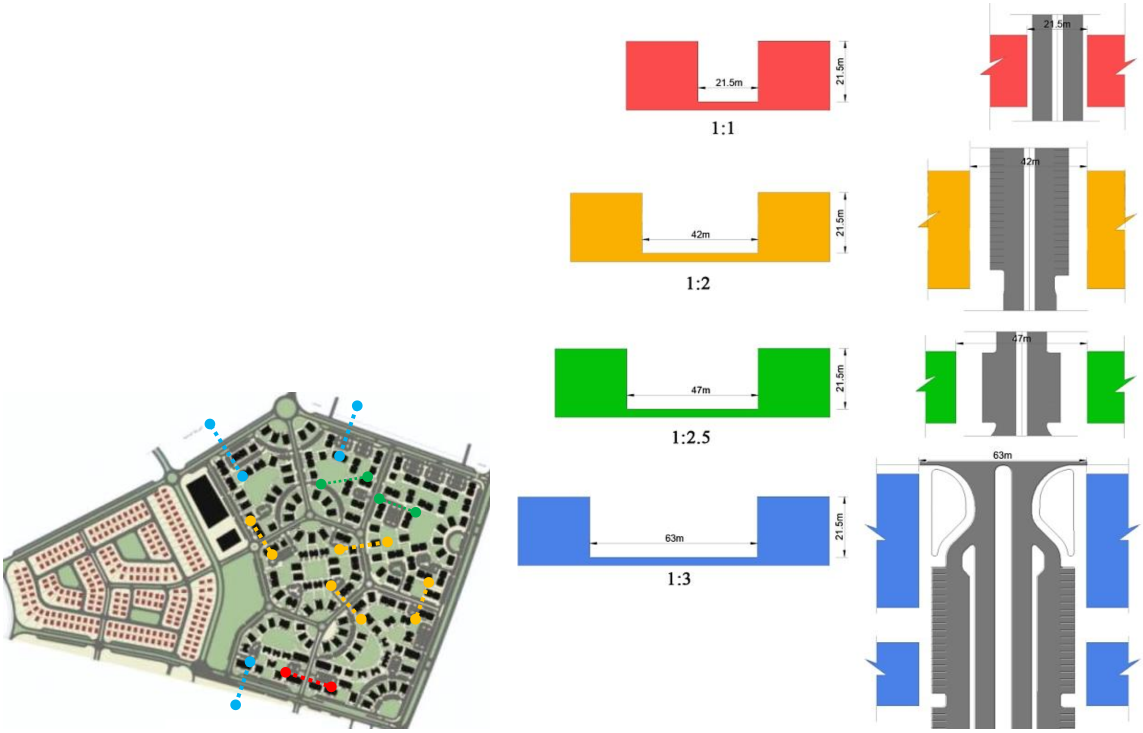


Figure (5.21): The preferred energy efficient street orientation to accommodate with the desirable winds
Source: (Talaat Moustafa Group, 2013) adapted by the author

III. <u>Solar Radiation:</u> As mentioned in the literature review, that street's proportion has many implications on the amount of solar radiation that hits the walls of the buildings. Usually streets' proportion is defined by the H/W ratio, as a higher H/W ratio result in lower heating of the urban streets and gives more shades, which in sequences support the pedestrian paths with shades and ease the solar radiation effect of heating. A high H/W ratio is more suitable in a hot climate such as in Cairo, particularly when pedestrian areas and walkability need to be encouraged (Givoni, 1998). In the case study the streets have high H/W ratios, as shown in figure (5.22). But actually, according to the analysis done by simulation software (Vasari), it was obvious that; the majority of the streets and the surfaces of the buildings are highly exposed to solar radiation, as shown in figure (5.23). Thus, extra shading elements and trees should be added to achieve the preferable shading for the pedestrian paths. Conversely, cars' usage is the most convenient way to commute through the area, as the streets are not provided with the basic requirements that support and encourage walkability. Figure (5.24) shows an example of the lack of shades' instruments in the streets and the parking spaces. In addition to that, figure (5.25-5.26-5.27) shows the results of the solar radiation analysis, according to the analysis done by the simulation software (Vasari).



Key Plan

Figure (5.22): Shows the streets H/W ratios
Source: (Talaat Moustafa Group, 2013) adapted by the author

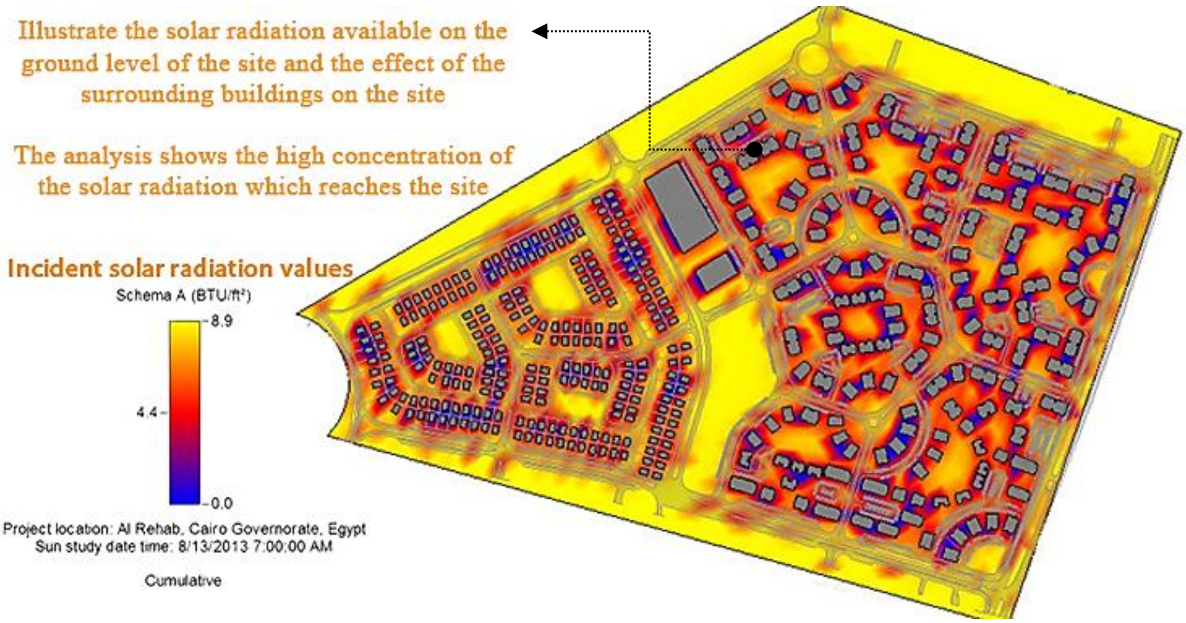


Figure (5.23): Solar analysis of the open spaces between the buildings
Source: Analyzed by Vasari program

Figure (5.24): Shows how much a parking lots effects with high solar exposure
Source: (Talaat Moustafa Group, 2013) adapted by the author

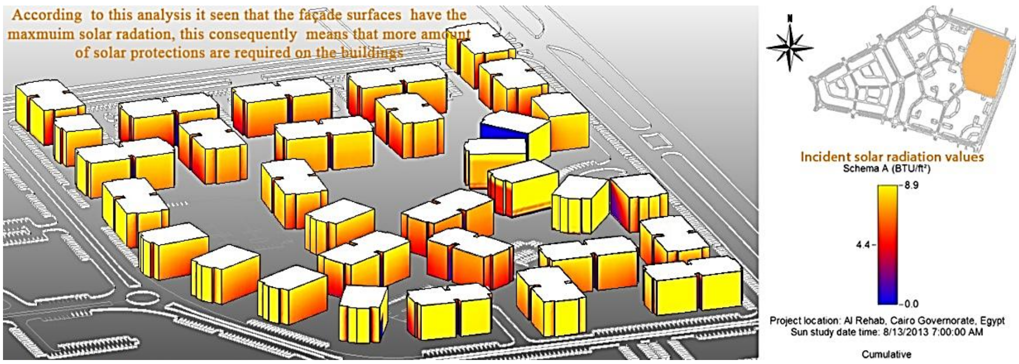


Figure (5.25): Solar analysis performed on the apartments' façades to show the amount of the solar radiation
Source: Analyzed by Vasari program

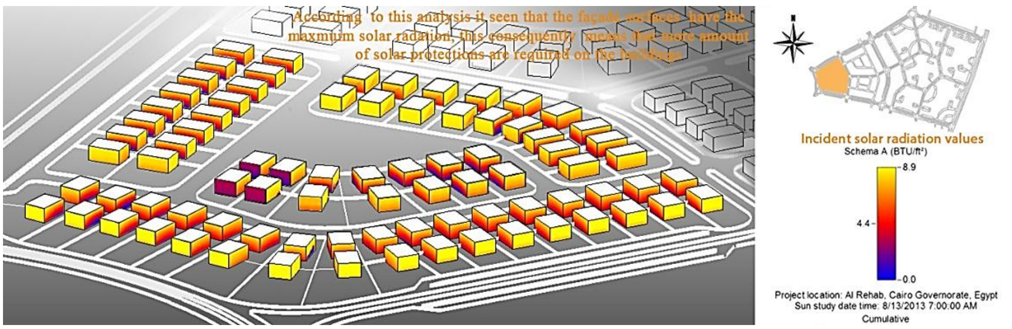


Figure (5.26): Solar analysis performed on the villas' façades to show the amount of the solar radiation on the buildings
Source: Analyzed by Vasari program

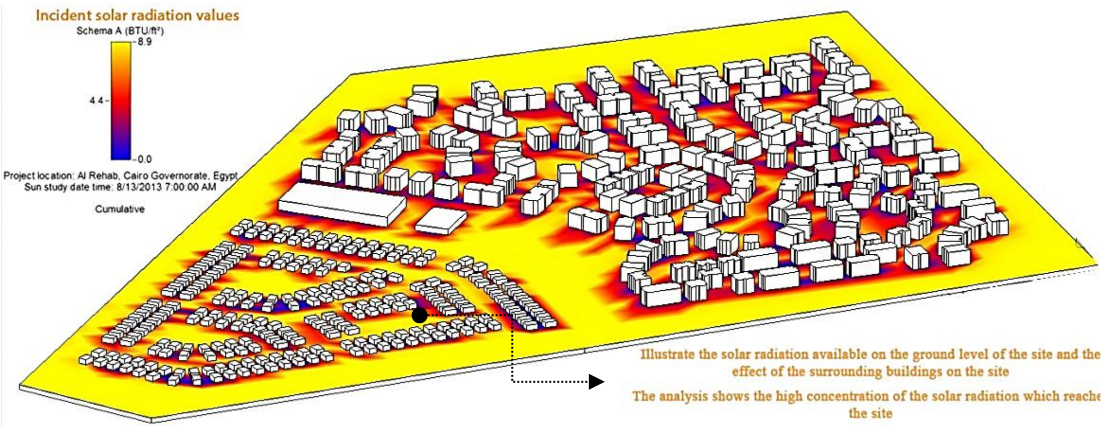


Figure (5.27): Solar analysis performed in the open spaces between the buildings
Source: Analyzed by Vasari program

Hence, for the ideal solutions, after aiming the building to catch the breeze, it is preferred to face the long sides of the building with most of the windows towards the south and north. Besides, the roof overhang can shade the walls and windows in the middle of the day and keep the sunlight away from the buildings' walls. In general, the main layout concept should take care about the proper street proportions and the distance between the buildings in order to keep sunlight off of building walls. In addition to that, a good solar orientation should also provide solutions for the pedestrian to take the advantage of long shadows.

IV. The Exterior Environment: In any sustainable neighborhood choosing permeable paving and reflective materials is preferred to reduce heat absorption and heat build-up (Building Smart Guide, 1997). In the case study, it was observed that the interlocked is the common material used for the sidewalks. It is a reflective paving material with a light color for the sidewalks, as shown in figure (5.28). That may be help in reducing the sunlight reflected in the house and lowers the surrounding ground temperatures.

Figure (5.28): Examples of the sidewalks in the residential areas
Source: (Al Rehab City, 2011)

On the other side, it is preferable to use most of the paved surfaces on-site concrete paving instead of traditional asphalt paving (Building Smart Guide, 1997). In the case study, the percentage of the asphalt surfaces are very high, which represent a large percentage of the total surfaces within the area. It represents almost 35% of the all areas of the neighborhood 8, as shown in figure (5.29). This percentage has a negative impact on the energy consumption. So, it is recommended to replace most of those asphalt surfaces with reflective paving materials such as the concrete, which made with white cement mixtures, light-colored to be used for driveways, roads and parking lots. As previously described in the literature review, the concrete paving reflects much more of the heat of the sun, which lowers temperatures and reduces the heat island effect (Building Smart Guide, 1997).

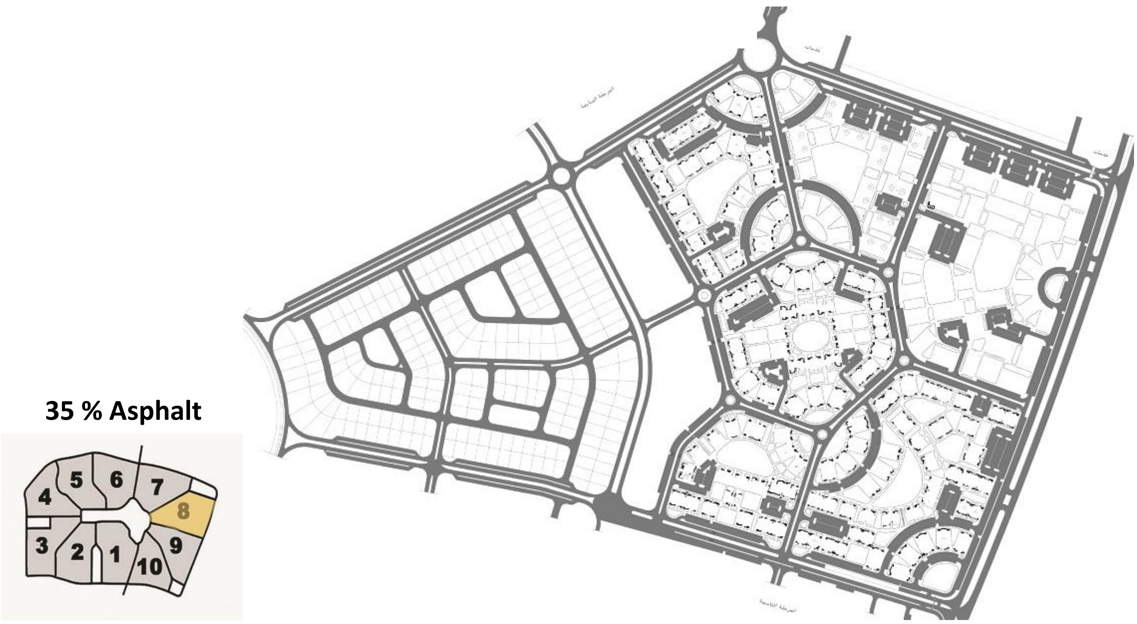


Figure (5.29): Shows the percentage of the asphalt surfaces within neighborhood 8 in Al Rehab City
Source: (Talaat Moustafa Group, 2013) adapted by the author

In the term of building colors, the light color should be used in the exterior surfaces, as the light color reflects sunlight and helps maintaining cooler temperatures within the building (Allen & McKeever, 1996). In Al Rehab, most of the buildings in the whole district are already in light colors and have high albedo surfaces, which help in reducing energy consumption. Figure (5.30) shows examples of some buildings within Al Rehab.

Figure (5.30): Example of the light buildings' colors in Al Rehab City
Source: (Al Rehab City, 2011)

V. <u>Water Features:</u> According to the study done by Majumdar (2002) which argued that, water is a very good modifier of microclimate. This study recommended to use the water features like fountains and moving water in the surrounding environment, in order to create breezes between water and land. Furthermore, those water features help in evaporating and cooling the surrounding air, especially in a hot and dry climate. In the Al Rehab City, the design of the whole district offers some water features in the landscape design which improve some of the outdoor temperature, which make outdoor areas breezy, as shown in figure (5.31).

Figure (5.31): Examples of the water elements used in the landscape
Source: (Al Rehab City, 2011)

VI. <u>Block Density</u>: Density standards in zoning districts targeted for sustainable neighborhood preferred to allow increased densities in the locations. As the low-density developments use nearly twice as much energy per square foot as the high density developments (Robertson, 2009). This means that, the low-density urban is more energy and GHG intensity by a factor of 2.0–2.5 than high density urban core development. In Al Rehab City, it has a population of 200,000 on an area of 1000 hectares, this means that the average density within the whole district is around 200 persons per hectare. The density varies according to the different types of the housing units, as it differs from villas and apartment buildings. It ranges from 100 persons per hectare in the villas' areas to 400 persons per hectare in the apartment building areas (Yousry, 2009). According to the analysis, it was obvious that; the previous population 400 persons per hectare can be within 88 units per hectare, when the average of the family members is 4.5 persons. While, in the villas' areas; the population is within 22 units per hectare. These percentages are within the range of the recommended densities in the different urban areas, which provide feasible amounts of ridership for mass public transport, support mixed functions and urban quality. As the study done by Falk & Carley (2012) demonstrated that, creating an efficient urban form requires a minimum net density of 30 units per hectare, as in the garden cities and some of the new towns. Thus, the case study exceeds the minimum density in the apartment areas. While in the in the villas' areas, the density is lower than the minimum density, which consequently increase the dependence on the private automobile.

In short, the overall planned population density in the project should support the concept of high density compact urban form, in order to reach a district which is protected from solar radiation, reduced the dependence on automobiles. As, higher density urban areas can support the economic feasibility of mass public transport and can achieve additional energy efficiency in the built environment. Another result is when streets are narrow, the shading of streets is maximized, which create a more comfortable microclimate for pedestrians. Also, when buildings provide shade for each other, this is consequently result a lower cooling load for the buildings. From another side, the built-up area in the neighborhood 8 at Al Rehab is around 20%, within this percentage the automobile dependence did not reduce. Moreover, this puts more pressure on the energy needed for travelling and moving within the area. This pattern did not decrease the proportion of exterior wall surface, also lead to high exposure of solar incidence, which heats up the surfaces of the buildings. While from the positive side, this pattern also allows more wind to penetrate between buildings. Figure (5.32) shows the built-up areas of the residential blocks and villas within neighborhood 8.

Figure (5.32): Different level of compactness within neighborhood 8 in Al Rehab City
Source: (Talaat Moustafa Group, 2013) adapted by the author

VII. Landscape: The literature showed that, green areas should take up more than one third of total neighborhood areas, this is almost the optimum percentage (Al-Hagla, 2008). Within neighborhood 8 in Al Rehab City, the green areas are around 30% of the total area, as shown in figure (5.33). Residential buildings are clustered in groups around green spaces. Besides, the trees are arranged along the two sides of the streets and around the parking areas. In addition to that, the project's design used the native plants and select the proper type of them, in order to maximize the shading of the building envelope. Also, the design depended on covering the ground with lawns rather than paving, to reduce sunlight reflected into the house and lower the surrounding ground temperatures (Yousry, 2009). This percentage has benefited the neighborhood positively in decreasing the temperature of the outdoor air, also in improving air quality and absorbing carbon dioxide which helps in reducing GHGs. Figure (5.34-5.35) shows examples of the green areas within Al Rehab City.

Figure (5.33): The green network within neighborhood 8 in Al Rehab City
Source: (Talaat Moustafa Group, (2013)

Figure (5.34): Shows the green areas around the parking areas
Source: (Talaat Moustafa Group, 2013) adapted by the author

Figure (4.35): Examples of the green areas around the apartment buildings
Source: (Al Rehab City, 2011)

VIII. Exterior Block Properties: As previously described in the study done by Robertson (2009) that, the building form should be with a design that maximizes the living space within a minimum envelope area, where the heat loss occurs. This means that the ideal building design should keep the corners and joints to a minimum, in order to reduce the possibility of creating thermal bridges through which heat can dissipate to the outside of a building. From the other side, the study also proved that, buildings with large footprints and a large amount of floor space far from the exterior of the building will require heat removal in the interior zone all of the year. In Al Rehab City, the design of the apartment buildings were with large footprints and with a large number of corners, which led to increase the heat loss and led to make the building inefficient, as shown in figure (5.36). Hence, in general, the project's should use the building mass configuration which is effectively appropriate to the context and climate. As, the preferred building configuration in this climate, is the linear mass which is seeking to minimize the corners and maximize the floor area in relation to the outside wall area.

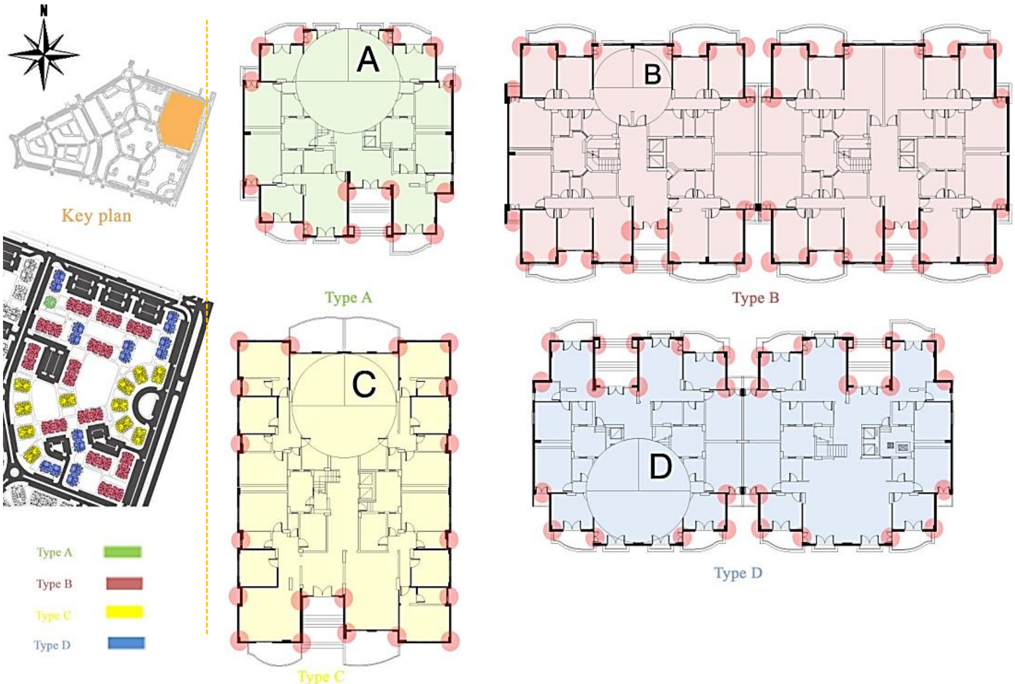


Figure (4.36): Shows the large number of corners in the apartment buildings
Source: (Talaat Moustafa Group, (2013) adopted by the author

5.6.1.2. Architectural Scale:

It is worth mentioning that, Al Rehab district mainly contains a variety of housing units, as it includes villas and apartment buildings. The heights vary from five stories for apartment buildings and two stories for villas. All apartment building areas are designed in groups, where clusters of the residential buildings enclose green open spaces and interconnected together by a pedestrian network, that is totally separated from the vehicles roads and parking lots. For the villas, there are 26 villa prototypes which range from 170 square meters in the semi-detached villas to 520 square meters in the luxurious ones, all of them with private gardens taking up at least 60% of the total plot area (Yousry, 2009). Figure (5.37-5.38) shows some examples of the villas and the apartment buildings within Al Rehab City.

Figure (5.37): Different examples of the villas within Al Rehab City
Source: (Al Rehab City, 2011)

Figure (5.38): Different examples of the apartment buildings within Al Rehab City
Source: (Al Rehab City, 2011)

I. Walls: As previously described in the study done by Donnelly (2010) that, building materials play very important roles in saving the building energy. The study showed that, any material being applied to the walls should be externally insulated and dense materials like: concrete, bricks, lime renders and other masonry. The study also concluded that, walls' materials preferred to be with U-values range from 1.1 – 2.4W/m²K, in order to absorb and store thermal energy. In the case study, it was observed that, most of the buildings are in light colors and have high albedo surfaces. It is worthwhile to consider that, albedo surfaces can save cooling energy use by directly affect in reducing the heat gain through a building's envelope. From the other side it has indirect effect by lowering the urban air temperature in the neighborhood (Misni & Allan, 2010). This means that, the design succeeds in selecting a reasonable building material, as shown in figure (5.39).

Figure (5.39): Example of high Albedo buildings' colors within Al Rehab City
Source: (Al Rehab City, 2011)

II. Roof & Ceiling: As described previously in the literature review that roofs play important roles in protecting buildings from sun rays during summer, in order to minimize heat gain (Climate & Comfort, 2005). Thus, it is preferred to use roofing system consists of dense materials and light colors (Hoyle, 2011). The design depends solely on the most common material used in insulating the roofs, which is modified bitumen. At the local level, this material is very common in Egypt and used usually. In addition to that, the design also ensure the using of the light color materials and high insulated materials (Talaat Moustafa Group, 2013) In general, the project should aim to reduce energy consumption by renovating all of the existing building's roof by increasing the rate of the insulation. Also, great effort should be done in developing new concepts of heavily insulated cool roof systems for all the new building.

III. Daylighting Techniques: According to the literature review, it is extremely important to consider daylighting strategies from an overall perspective. As, it is not just a question of illumination, but also the interactions between light quality, climate, building functions, orientation, occupants, solar gains and buildings' design to reduce energy using in the buildings. In Al Rehab City, the design did not pay attention to daylighting strategies used within the home design, especially for the building width. As the literature showed that, the shape of the building should be with long, narrow sections arranged to allow daylight into the floor as much as possible (Taiao, 2008). But actually, it is apparent from the analysis that, all the buildings' shape at Al Rehab results in no daylight access. As buildings' width is of type A, B, C, D is about 18m, 22m, 21m, 19m, as shown in figure (5.40). Consequently, this exceeded the maximum width for achieving daylighting in any building, which leads to the direct increase in the energy needed within the building. In general, the passive design strategies which optimize natural daylighting access should be developed in line with climatic. Hence, all the new buildings should be with narrow building shapes or they can be designed around the courtyard with a central open space, in order to penetrate the daylight deeply inside the building.

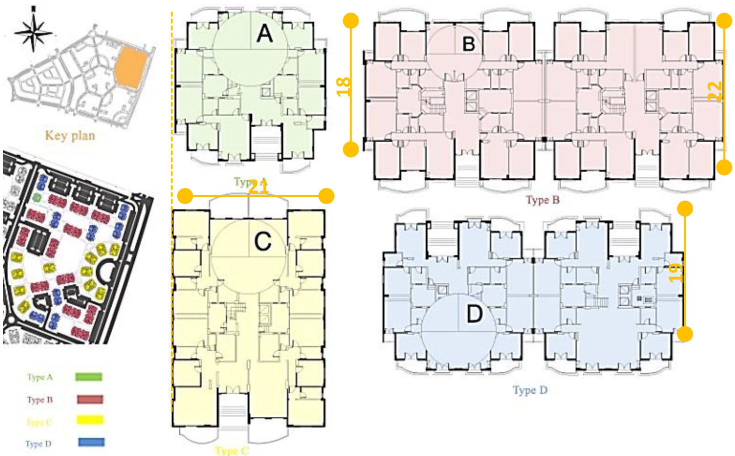


Figure (5.40): Example of buildings' width in Al Rehab City
Source: (Talaat Moustafa Group, 2013) adopted by the author

IV. Openings: Windows are the most important elements of solar designs, which can reduce heating, cooling and lighting needs of the house. It is worthwhile to consider the best orientation of the window, its frame and the size of the glass, in order to maximize solar heat gain in winter and minimize it in the summer. Thus, to reach the effective design, the building should be with large window surfaces facing in the north. While in the south windows, the glass areas should be reduced, besides overhangs or other shading devices should be used to prevent excessive heat gain. Additionally, the east-west-facing windows should be with limited numbers (Hoyle, 2011).

In Al Rehab City, the design did not pay attention to the differences between the north and the south elevations. The architects used in their design large areas of windows on the south side, although the external shading devices did not use in the design. So this led to a great increase to the excessive heat gain. Moreover, this has negative impacts on the homes' energy efficiency, their comforts and their indoor air quality. While in the east-west elevations, the design already limited the numbers of the east-west facing windows which have positive effects somehow on the indoor environment. Figure (5.41) shows examples of some buildings' elevations within Al Rehab. Hence, in general, it is recommended to renovate all the existing windows. Besides, all the new buildings should not exceed the ideal percentage for the window wall ratio. In addition to that, they should promote the concept of using the proper window's location, size, type and insulation.

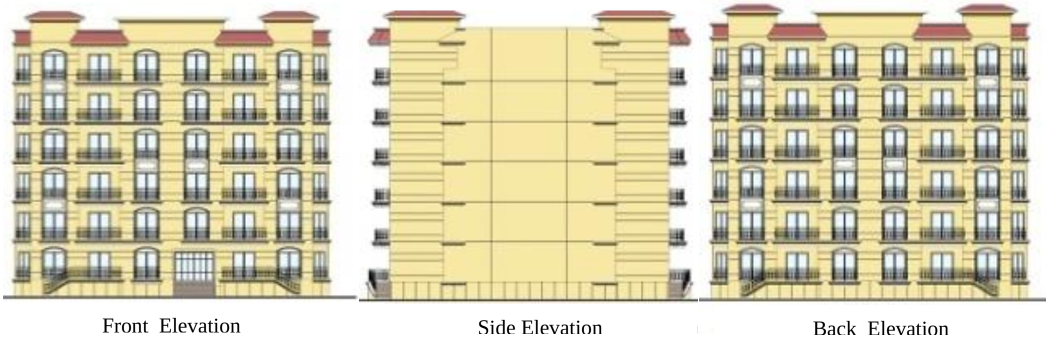


Figure (5.41): Example of buildings' elevation within Al Rehab City
Source: (Talaat Moustafa Group, 2013)

V. Shading Devices: The literature showed that, shading is used in reducing the ingress of solar gain, the effective temperature and the glare (Baker & Steemers, 2005). In the context of Al Rehab, there is a shortage in the shading devices along the pedestrian paths, although the external shades are very important to encourage walkability. From another side, the shading of buildings on each other cannot be used as they are far away from each other. This consequently increases the solar incidence on building surfaces which increase the energy needed for cooling indoor spaces. Thus, it is recommended to add some shading instruments, both on the building surfaces and above the pedestrian paths, in order to make outdoor areas breezy and reduce the indoor effect. Besides, the landscape elements should be used over the parking areas, the outdoor spaces and the pedestrian paths, in order to decrease the outdoor temperature and encourages the resident to walk. Figure (5.42) shows the lack of shading devices in some of the building elevations within Al Rehab.

Figure (5.42) Lack of shading devices at the buildings' elevation in Al Rehab City
Source: (Al Rehab City, 2011)

VI. <u>Natural Ventilation System:</u> As described previously in a study by Taiao (2008) that, the most suitable shape and layout for naturally ventilated buildings is very similar to that discussed for daylighting. The study also showed that, the natural ventilation strategies will only be effective up to the maximum distance of around 15 meters, this means that the long narrow floor plate is the preferred building form. In the case study, it is apparent that the buildings' shape does not support the cross ventilation. As previously mentioned that, the buildings' width of type of type A, B, C, D is about 18m, 22m, 21m, 19m. Also the design did not pay attention to the cross flow through openings, which increases the energy needed for cooling indoors. In addition to that, the buildings' design did not depend on using added techniques to enhance ventilation inside the building, such as solar chimney or wind cowls. Hence, in general the passive design strategies which optimize natural ventilation access should be developed in line with the climate. As all the new buildings should be with narrow building shapes or they can be designed around the courtyard with a central open space, in order to allow for increased natural ventilation inside the building as opposed to deep buildings.

VII. Insulation: The literature showed that insulation is used in reducing the absorption of the solar gain and reduce the effective temperature (Baker & Steemers, 2005). Hence, in the context of Al Rehab, the project should aim to reduce energy consumption by renovating all of the existing buildings' shell and increasing the rate of the insulation for the walls, roofs, as well as windows. Also, great effort should be done in developing new concepts of heavily insulated systems for all the new building.

5.6.2. Energy Distribution:

As mentioned before in the literature review that, the second step to achieve energy efficiency is to the distribution grid systems, which will allow a further saving. It is important to note that; is objective will be reached by improving the existing transmission and distribution grids through the introduction of smart devices and a capillary communication network such as the smart grid. Those existing transmission and distribution grids should be redesigned to become two-way channel systems, in which they depend on electrical infrastructure that enable real time interactions among the devices, systems and operators. As well as, this electrical infrastructure should also allow the integration of distributed energy generation systems such as like wind, solar heat and geothermal heat, thus to decrease the dependence on the fossil fuel resources. Those grid technologies offer ways not just to meet the challenges to improve the security of supply and to lower carbon emissions, but also to develop a cleaner energy supply that is more energy efficient, more affordable and more sustainable (Burns, 2009 & Davoli et al., 2012).

Thus, it is recommended to use the smart grid with its system of controls and smart meters. As the study done by Smart Grid. Gov (2013) approved that this system effectively connect all the mini-power generating systems to the grid and provide data about their operation to utilities and owners. Furthermore, it is used to know what surplus energy is fed back into the grid versus being used on-site. From the other side, the recommendation for every home owner is to use the smart meters. It is preferred to install them in the place of the old mechanical meters, these meters operate digitally and allows automated and complex transfers of information between the home owner and his energy provider. Besides, many of the appliances should also be networked together, allowing the access and the operations through the energy management system. These appliances like smart air, smart refrigerators and smart dishwashers. To sum up, it can be said that, it is preferred to use Building Energy Management Systems, which refer to the computerized systems that attempts to control all the energy consuming operations in the building. But actually, this is expected to take a few years of work to establish a fully integrated system like that.

5.6.3 <u>Energy Generation:</u>

Finally the last step is the using of renewable energy sources and actively renewable strategies to reduce the primary energy demand. As it' was explained before in the study done by UN-HABITAT & UNEP (2009), that is the most expensive step, while offering the lowest relative environment impact returns. This means that, increasing the initial costs of applying renewable energy technologies and smart technologies will represent a financial barrier and a technical constraint of turning exiting community like Al Rehab to increase its energy efficient, but it can be applied in the future. It's worth mention that, renewable energy can be integrated by allowing flexibility in design and planning of new communities of a building, plot, neighborhood or district level. It needs to consider space allocation and requirements from the start, as well as it needs to be considered according to the site specific conditions. Thus, the following part has suggested some techniques which can be used in the long run. These techniques can be classified into two categories like:

1. <u>Off-site Renewables:</u> The project should promote the concept of generating energy from off-site renewable power generation as a source of energy to power the grid and the buildings instead the energy produced from the fossil fuel resources. Examples of the off-site renewables are:

- <u>Solar Farms and wind turbine:</u>

In some neighborhoods, solar or wind power generation may be feasible, depending upon local resource characteristics and electric rates. In the case study, it is recommended to use the coasts of the Mediterranean Sea even more by creating more wind farms same like " Zafrana wind turbines". On the other side, the potential that Egypt has one of the highest levels of solar irradiance in the world, can use to add more solar farms. As described previously, that using of solar or wind for power generation allows reduction in the amounts of electricity that must be imported into the neighborhood via the community electric grid. Such reductions not only make the neighborhood more self-reliant and sustainable, but also extend the capacity and life of the community electric grid (Allen et al., 1996).

2. <u>On-site Renewables:</u> The project should promote the concept of using the urban spaces and buildings' shells for the integration of the renewable energy, in order to produce energy which can be used within the buildings.

2.1. <u>Urban Scale:</u> For the outdoor spaces they can use the roof canopies over parking areas, bus stops, as well as the public squares. Examples of the on-site renewable which can be used in the urban spaces are:

- <u>Photovoltaic:</u> PV panels are recommended in the areas with many hours of sunlight like Egypt and the excess energy can be sold to the electricity grid. The panels are relatively easy to integrate into the urban designs of the neighborhood (Charles, 2006). It can be used above the parking lots as shading devices or can be used on the exterior lights: PV / Smart light, as shown in figure (5.43-5.44).

Figure (5.43): Example of PV panels over the parking lots
Source: (Lazarus, 2002)

Figure (5.44) Example of the smart light
Source: (Zedfactory, 2014)

- <u>Wind:</u> It is recommended to use "Mini Wind turbines", which are designed especially for urban areas. They should be insulated in area without building or other elements that can block the wind. They can be large scale wind power turbines used in the open spaces, as in Wilhelmsburg. All the negative urban spaces in Wilhelmsburg are renovated and used as sources for energy generation.

The wind turbines can be connected to the power network or it can be used as a power to the applicants inside the home (PRWEB, 2010).

2.2. Architectural Scale: From the other scale, each home can have its own micro wind turbine, PV installation and solar thermal panels serving its own hot water store. Hence, all the buildings can exploit every opportunity for producing energy through their own power generation, such as integrating the photovoltaic units with their facades and their roofs. Examples of the on-site renewable which can be integrated in the building's shell such as:

- PV Panels: The literature showed that, the panels are relatively easy to integrate into the design of the houses and power systems. PV systems are typically roof mounted or ground-mounted, although they can also be integrated into vertical walls or roofing materials. Although, the vertical PV system can replace cladding panels on unshaded facades in the south side, they are cost effective and produce roughly less than the energy of a roof panel (Charles, 2006). So it is better to use the roof panels in the case study, where they are more flexible to be fixed in order to increase generation. Figure (5.45) shows an example of roof mounted panels.

Figure (5.45): Examples of roof panel PV cells
Source: (Lazarus, 2002)

- Solar heating system: It is being tested as a source of thermal energy for single and double-effect absorption chiller systems. According to the analysis of all the previous examples, it is recommended to be used as a source which could meet a significant portion of the neighborhood's hot water demand. This system typically includes roof mounted panels or evacuated tubes, an insulated storage tank, pipes, pumps and controls. In short, the evacuated tube collectors will be roof mounted to provide domestic hot water and a base load that can be used for de-humidification (Baker & Steemers, 2005).

5.7. Conclusion:

According to the previous observation, it was obvious that, the design of the selected case study does not meet most of the sustainable design principles from the environmental side, although it is socially and economically succeeded. Actually, Al Rehab City offers the model of the lively and livable city, in which the residents satisfied and feel better about their social and economic status more than the traditional housing areas. It makes them feel safe, secure, keeping out crime and controlling the quality of services which provides good quality of lifestyle. Hence, there is much agreement that Al Rehab City is one of the most successful communities of the social and the economic aspect, but it can not be considered the best settlement that applies the proper design principles to decrease its impacts on the environment. So far, it is hardly to be considered it as a prototype of the Egyptian communities which have fewer impacts on the environment. Thus, this result shows that there is a pressing need for improving urban governance and more comprehensive planning, including system solutions for the environment. Hence, the next chapter underlines the necessity to develop the design principles and update the current urban planning regulations, in order to achieve a conceptual framework available to create a sustainable neighborhood that fulfils energy future requirements.

The following table (5.1) showed the result of the analysis of the case study, which is based on comparing between the designing of the Al Rehab City against the design principles of the sustainable neighborhood. The points of the analysis discussed according to the same design criteria, which used in analysing the previous examples. The criteria mainly indicated how far the project as a whole district met the sustainable neighborhood principles. On the other hand, it showed a summary analysis for the design of the neighborhood 8 in Al Rehab City in comparison with the energy efficient design principles. As a conclusion, the case study analysis shows that the design of the Al Rehab City did not fulfil most of the design principles extracted in the literature review chapters. As, the neighborhood is already suffering from a lot of problems. Furthermore, the design is applying many strategies that employ high energy consumption and did not fulfil most of the principles of the sustainable neighborhood.The table used the following key in order to check the major elements in the case study:

- ● Existing and Efficient = 1 point
- ⊖ Existing but not Efficient = ½ point
- ⊗ Do not Exist = 0 points

Design principles		Compliance with the principles
	1. Land-Use System	●
	2. Mobility System	⊖
	3. Waste Management	⊗
	4. Water Management	⊗
	5. Housing	⊖
	6. Natural Systems	●
	7. Materials Conservation	⊗
	8. Food System	⊗
	9. Energy Efficiency	⊖
Energy Consumption		
Urban	**1. Orientation**	⊖
Urban	**2. Wind Direction**	⊖
Urban	**3. Solar Radiation**	⊖
Urban	**4. The Exterior Environment**	⊖
Urban	**5. Water Features**	●
Urban	**6. Block Density**	●
Urban	**7. Landscape**	●
Urban	**8. Exterior Block Properties**	⊗
Architecture	**1. Walls**	●
Architecture	**2. Roof & Ceiling**	●
Architecture	**3. Daylighting Techniques**	⊗
Architecture	**4. Opening**	⊖
Architecture	**5. Insulation**	⊗
Architecture	**6. Shading Device**	⊗
Architecture	**7. Natural Ventilation**	⊗
Energy Distribution		
	Smart Grid	⊗
	Smart Home	⊗
Energy Generation		
Urban	**1. Off-site Biomass / Biogas plant**	⊗
Urban	**2. Solar Farms**	⊗
Urban	**3. Wind Farms**	⊗
Architecture	**1. Photovoltaic systems**	⊗
Architecture	**2. Solar water heaters**	⊗
Architecture	**3. Geothermal Heat Pump Systems**	⊗
Architecture	**4. On-site Biomass / Biogas plant**	⊗
Architecture	**5. On-site Wind Turbine**	⊗
Total points		11Points

Tables (5.2): Shows the relation of Al Rehab City with the design principles
Source: Adapted by the Author

5.8. Comparsion

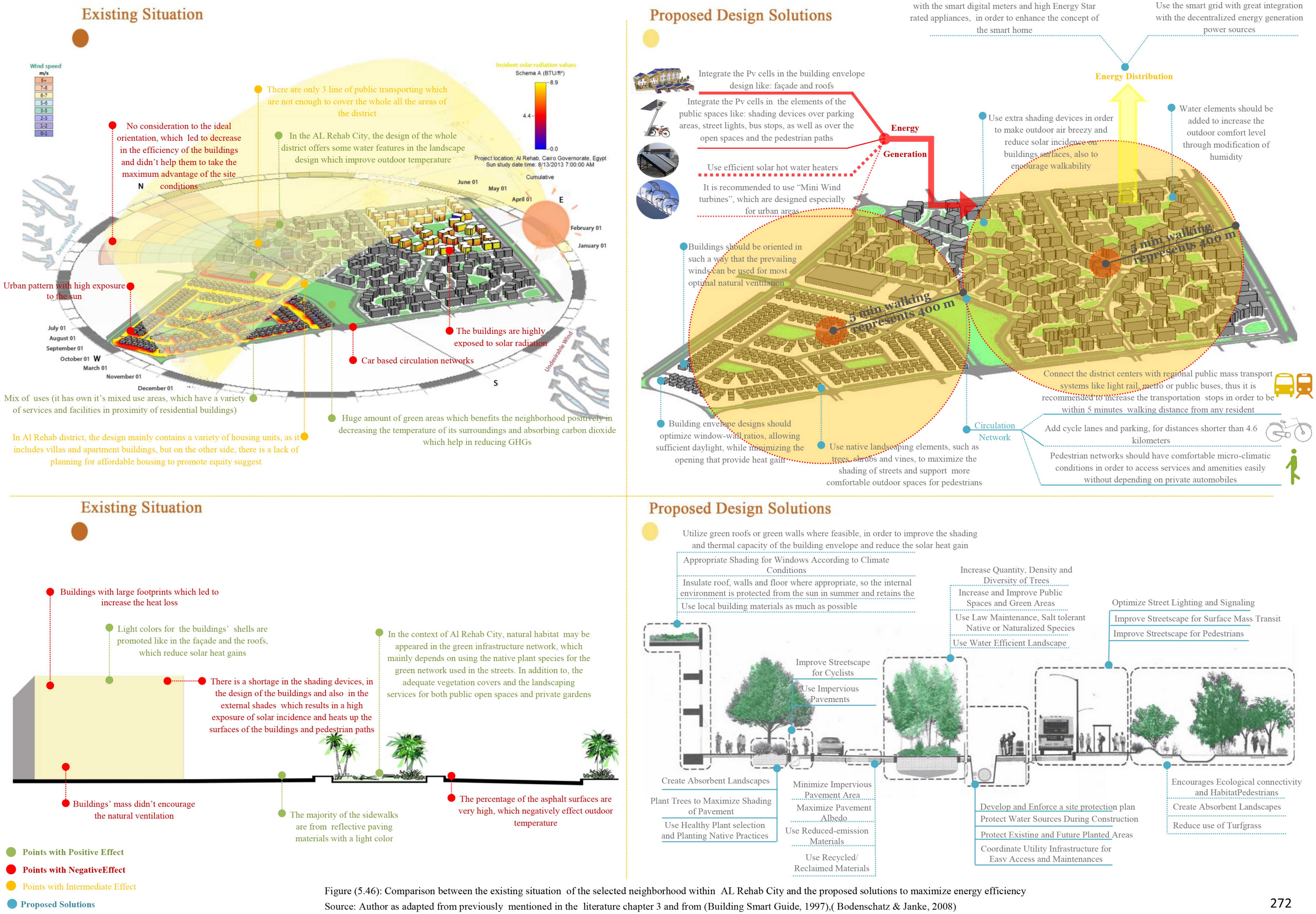


Figure (5.46): Comparison between the existing situation of the selected neighborhood within AL Rehab City and the proposed solutions to maximize energy efficiency

Source: Author as adapted from previously mentioned in the literature chapter 3 and from (Building Smart Guide, 1997),(Bodenschatz & Janke, 2008)

6. Chapter Six: Conclusions

This chapter summarized the conclusions from the research and explored to what extent the research findings fulfilled their aim and objectives, as well as answering the research questions. It mainly underlined the necessity to develop the design principles and update the current urban planning regulations in order to achieve a conceptual framework available to create a sustainable neighborhood that fulfills future energy requirements. Following this, there was a critical reflection upon the approaches employed in this research to carry out the analysis steps on the local level, in order to show the required adopted process to develop the Egyptian New Settlements. Finally, it ended with suggestion for further studies, which could not be discussed within the context of this research, in order to reach more concrete results.

6.1. The Conclusions and Recommendations from the Research:

After analyzing many examples and projects in many countries, it is clear that; the sustainable development is now becoming the basic concept for solving problems, meeting the acute challenges and improving the living conditions of people without neglecting the needs and life chances of future generations (Goell et al., 2009). It is also important to note that; the road to sustainable development should integrate the social and environmental factors into the economic framework of national development. From another perspective, it is proved that creating new settlements with the basic requirement of the future needs is the key aspect of sustainable development (Thomas, 2003). This may be extended to its importance in decreasing the gap between buildings and cities at the regional systems as a whole (Hargreaves et al., 2004)

As a result, it is vital that the new residential neighborhoods should be attractive places with good quality and green public spaces that help to create healthy communities (Razavi, 2012). To reach this vision towards sustainability in urban form, those new settlements should provide good local infrastructure, transport, water and waste management, energy supply and all of the other aspects of vibrant city living. In addition to that, it should also be able to reproduce its population, be self-sufficient in terms of its own employment, service requirements, as well as be able to deal with all of this, while enhancing environmental quality without damaging its precious life support functions (Thomas, 2003). So, wherever possible, such provision should be central to the future plans, in which neighborhoods are part of the solution to environmental problems not part of the problem (Thomas, 2003). This means that the new growth points are not about building more homes, but also about better homes, which built to high standards both in terms of design and environmental impact (Razavi, 2012).

Accordingly, a revolution in the ways of building and designing homes and neighborhoods should be done. This mainly means new skills, partnerships and business models should be promoted for builders, energy suppliers and other stakeholders. Moreover, in general, governments should tend to explore new approaches in order to overcome the greatest challenges they faced in achieving liveable cities with a good quality of life to their residents. These challenges are how to improve the problems of the existing and the new cities to be more self-sufficient, physically and socially sustainable, while meeting the growing demand on the housing sector. Hence, this means that the strategic housing decisions that the governments will adopt on the next few years should be well adopted according to their importance to the life of the next generations (Department for Communities and Local Government, 2007).

In general, only such a holistic approach can achieve realistic solutions, substantial and equally distributed improvements. The many examples described in this study may give an inspiration for concrete action plan, in order to reach healthy and ecological settlements in general and maximum energy efficiency in particular. This action plan proved that the governments have to think globally, while acting locally. This may be stands for a new, comprehensive and integrated approach that have the essence of sustainable development (Price & Tsouros, 1996). The wide scope for local actions mainly depends on the role of the government to find ways of dealing with sustainability practice, which includes strategic vision or programs for sustainable development, provision of monitoring to ensure effective implementation of the guidelines, as well as promote the concept of well controlling and managing among the different responsible sectors and stakeholders. The following figure (6.1) illustrates the inspired framework towards sustainable development which focuses particularly on maximize energy efficiency.

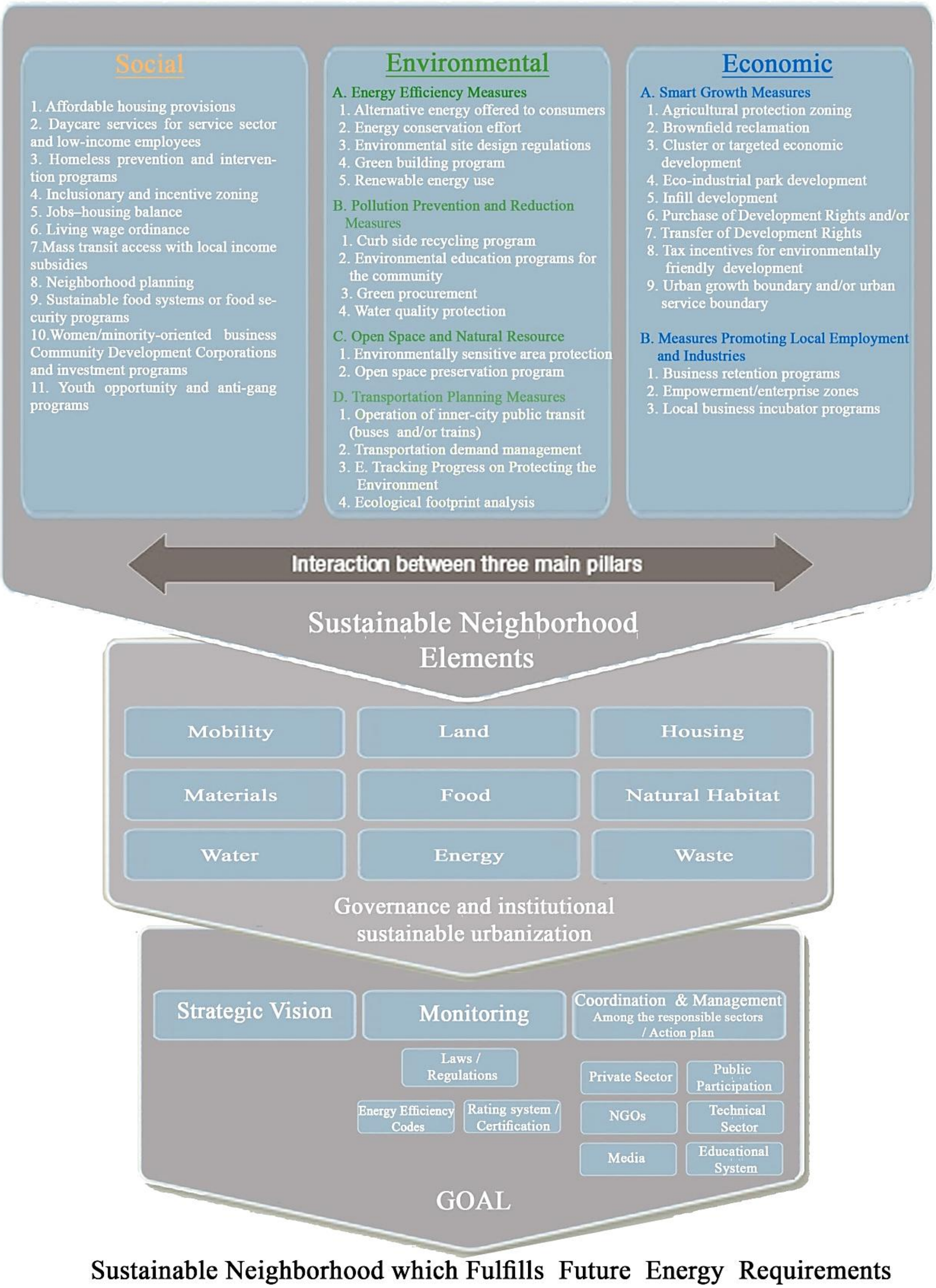


Figure (6.1): Illustrates the inspired framework of sustainable urban development
Source: (Rasooli et al., 2010 , Smith, 2006) adapted by the author

6.2. Implementation on the Egyptian New Settlements:

Before going to discuss how to implement the previous framework on the new settlements in Egypt, it is quite important to mention; the results of the analysis of the case study and the national example in comparison to the guiding principles of sustainability. According to this analysis, it seems that the Egyptian government encourages the expansion in designing new settlements in the desert in order to accommodate the overpopulation growth and attract part of the overpopulation in the existing cities (Shalaby, 2000). But with this expansion in designing new projects, no regard was given towards the environmental impacts specially the energy efficiency. Also, it was apparent that the majority of the new settlements in Egypt are only carefully designed to target specific groups not all the sections of society and they were mainly built without taking into consideration all the aspects of sustainability in order to reach an integrated sustainable development path. In general, it is expected that the new settlements around Cairo will be extended during the coming years to accommodate with the demand and pressure on housing (Goell et al., 2009). If this expansion remains with the same rate of the conservation of the resources and without regard to the environmental degradation, serious problems are expected to happen (Price & Tsouros, 1996).

Based on the analysis of the example of the Al Rehab City, it was obvious that, the design of the settlement did not meet most of the sustainable design principles from the environmental side, although it is socially and economically succeeded. The company of Talaat Moustafa Group just took the head to establish a fully-fledged new settlement in the desert in order to attract only the middle and high-middle income groups. This mainly represents a negative point, as the project should take care of all the sections of society without discrimination and not only specified for a specific group (Goell et al., 2009). Added to that, the developer of the project only focuses on special services, in order to be the first housing compounds in the New Cairo, which distinguished than the other communities with its special features and not with its environmentally healthy life (Yousry, 2009). This proved that, building new cities in desert areas were only done to reach special reasons which were totally away from the environmental direction.

Besides, in the example of the El Gouna, the Orascom Development Group did not achieve what they targeted for to be environmentally friendly. As described previously that, the goals of Green Gouna are to help in developing the resort as an ecotourism destination and also reducing their carbon footprint. Although the final project or the final outputs proved that, the city can only be described as a good model for development, but not for environment sustainability (Eakin, 2012). This may be due to the absence of monitoring systems for the projects, which should check on the progress in terms of timings and the various targeting included in the original reform measures.

In short, all of these previous analyzes and critics were proved that all the new projects have been built with no regard towards their environmental impacts in general and the energy efficiency particularly. It was proved that, the majority of the projects in Egypt are only done to be just for achieving business and financial succeed. Those projects have become places for doing business with millions of vacuum housing rather than places where communities live. This may be extended to the reason that; the Egyptian government did not monitor the projects or even support the private sectors, which target to establish environmentally friendly projects (Goell et al., 2009). As a result of that, there is a pressing need for improving the urban governance regulations and rules to manage the building of the new settlements which includes system solutions for the environment. Add to that, the government also has a major role to encourage the private and the business sectors either by applying a tax-free policy in order to attract them and encourage them to help in developing the green technologies in Egypt. In the light of this, the following part showed the closes relation between the previous inspired framework and the existing conditions in Egypt, in order to show the deficiencies and positive points in the exiting government’s roadmap.

- Vision in Egypt:

According to the framework, it is obvious that the first principle in order to achieve sustainable development should be the vision of the strategic planning (Bayoumi et, a.l., 2007). In Egypt, efforts are being coordinated through the Ministry of State for Environmental Affairs with all concerned stakeholders to draft its own "National Sustainable Development Strategy". This framework aims to create harmony between economic and social national policies, as well as the various environmental components in Egypt. It is also worthwhile to consider that, energy is the major component of this national sustainable development strategy. Actually, the major call was for a sustainable long term vision for the energy supply and demand balance scenarios, which include the maximum use of all available renewable resources (Georgy & Soliman, 2007).

For this reason, a ministerial committee has been established for monitoring this strategy, headed by the Minister of State for Environmental Affairs and assisted by a technical group constituted of representatives of all concerned ministries. There are numerous objectives set up by this strategy that reveal the need for achieving the sustainable development. Among those objectives are: economic development and increase of resources, protection of natural and environmental resources and environmental conservation, as well as social justice in resource distribution, education, services and social integration. The focus was mainly on the second category related the environmental objectives as well as environmental related objectives in the other two categories (Georgy & Soliman, 2007).

- Monitoring Methods:

The next step should be monitoring and evaluating, which involves checking the progress of the projects compared with their objectives in order to evaluate the succession in meeting the targets that have been set. Added to that, it also involves checking on the progress in terms of timings and it should be done on a periodic basis, at least annually (UN-HABITAT & UNEP, 2009). This monitoring system may be depends mainly on the laws and regulations, which can be enforced by extra codes and certificate. Actually, in the terms of the law, there are a wide number of issues which can be covered, as it was more focused on the administrative and juridical part of the process of construction rather than design or building determinants (Ayyad & Gabr, 2012).

As previously mentioned that, there is a deep need to reshape the current legislations and codes in Egypt require reshaping in order to accommodate with the sustainability themes which spread all over the world. This step should be started by revising the existing local building laws and regulations, as it is widely known that, the constructions and urban planning projects are under law no.119, which published in the year 2008, it can also be known as the “Unified Building Law”. It's also worthwhile to mention that, this law was released by a presidential decree and ratified by the house of parliament on the 11th of May, 2008, thus in order to regulate the process of building and construction of the residential projects in the whole republic. There are numerous issues that this law covers, among those issues are: the regulations about national planning, regional planning, city planning, land divisions, unplanned zones, as well as the special zones (Ayyad & Gabr, 2012).

Added to that, it is also worthwhile to consider that, the regulations which permit practice for the projects in the new cities are released by the New Urban Community Authority (NUCA). As it is widely known that, it is an agency under the Ministry of Housing, Utilities and Urban Development, was established according to law no. 59/1979. It was established with a main objective for controlling the new cities by promoting the regulations and the official permits, which help in creating new civilized centers which can help in achieving community stability and economic prosperity. On the other side, there is also the City Department of each new city, which is responsible for monitoring the building and the construction of the residential projects. In addition to that, it is mainly assured that the construction is taking place accordingly with the regulations and given permits (NUCA, 2008).

From a general point of view, it was proved according to the study done by Ayyad and Gabr in (2012) that; there are a lot of deficiency points in the current regulation which is the Unified Building Law. The study also argued that the law did not take green architectural concepts and many contextual and health concerns into consideration, as there are some points that are crucial for this law to be truly green, as shown in table (4.3). It's worthwhile to mention that the study is mainly based on the analysis done to investigate the main building code in Egypt, which is the Unified Building Law No.119/2008 from the green point of view. The study mainly depends on criticism of selected articles from the law, as the selection of these articles is based on their contradiction with green concepts. It's worth mentioning that, the order of the articles is the same order of their occurrence in the text of the law.

<table>
<tr><th>No. of the Article</th><th>Unified Building Law No.119/2008</th><th>Analysis</th></tr>
<tr><td>Article 2</td><td>This article explains the strategic plan, as it is the plan that determines the future vision of urban development and could be on the level of the nation, a region, a governorate, a city or a village. It includes goals, policies and plans for economic and social development and the built environment that is essential for sustainable development. It also states the future needs for urban expansion, land use, and the programs, priorities, mechanisms and financing sources on the planning level.</td><td>The study argued that, the article is concerned with the formulation of strategic plans for the different planning levels, in order to achieve a ‘sustainable development’ for a developing country like Egypt. However, it does not represent a whole framework for the whole country that states the overall sustainable vision for the next decade or so. The study also demonstrated that, there must have been a unified development goal, such as transforming the society from being agriculture based to being industrial based, or even stating that the unified goal for the nation is to develop a balance between agriculture, services and industry.</td></tr>
<tr><td>Article 15</td><td>This article shows that the national planning and urban development authority put down temporary building requirements for the existing areas which have no building regulations, especially those concerning street networks and building heights that fulfil the requirements of natural lighting, ventilation, architectural and urban character, safety and the environmental requirements according to the density described by the executive appendix for this law. It is prohibited to increase a building height to more than 1.5 times the width of the street on which it lies, with a maximum height of 36 meters. These temporary regulations are effective until the aforementioned strategic and detailed plans are prepared and ratified.</td><td>The study demonstrated that, the article accidentally follows one of the green concepts by emphasizing that each region must have its own strategic and detailed plan from which its own regulations evolve. However, it has not mentioned that each local set of regulations or strategic plans should be based on local climatic and cultural research that analyses the local natural and societal context. It has also emphasized on the importance of achieving natural lighting, ventilation and keeping the architectural and urban character. But it has put a superficial temporary regulation limiting the height to 1.5 times the width of the street with a maximum of 36 meters, disregarding whether this would satisfy the aforementioned health and environmental concerns.</td></tr>
<tr><td>Article 93</td><td>The article shows that, the clear height from the floor finishing surface to the bottom of the ceiling must not be less than 2.7 meters. However, it can diminish down to 2.3 meters in entrances, toilets, corridors, laundry rooms, guard rooms and the likes in a range that does not exceed 25% of the floor area of the room.</td><td>Here, the criticism depends on the fact that, the lawmaker has put a minimum for clear height that only spatial causes like furniture, chandeliers, and the passage of users. From the environmental point of view, the study argued that such a height is not adequate for cross ventilation and natural light to penetrate the depth of the architectural spaces. The study also explained that the contractors always stick to minimum as it comes to dimensions, except for total building height, in order to save money and create more selling opportunities.</td></tr>
<tr><td>Article 94</td><td>The internal floor areas and the shorter dimension of any of the building’s rooms must not be less than the following:
<table>
<tr><th>Use</th><th>Minimum Area (sq.m.)</th><th>Minimum dimension (m.)</th></tr>
<tr><td>Dwelling Rooms</td><td>7.5</td><td>2.5</td></tr>
<tr><td>Toilets</td><td>0.80</td><td>0.80</td></tr>
<tr><td>Kitchens</td><td>3.00</td><td>1.50</td></tr>
<tr><td>Bathrooms</td><td>1.50</td><td>1.20</td></tr>
<tr><td>Guard rooms</td><td>5.00</td><td>2.00</td></tr>
</table></td><td>The study shows that that, the article suggests that a space with dimensions 2.5x3.0m is adequate for a bedroom or a living room, a space 0.80x1.0m is adequate for a toilet, a space 1.50x2.00m is adequate for a kitchen and a space 2.00x2.50 is adequate for a guardroom. The study also argued that, such room sizes are already implemented in many housing projects known as “Youth housing projects” which spread in a wide number of new cities. In general, the study concluded that, such spaces have nothing to do with any environmental or health concerns and do not provide users with any functional or even psychological satisfaction.</td></tr>
<tr><td>Article 96</td><td>The article shows that, each room in residential buildings must have one or more openings to a street or an inner court, in order to provide natural lighting and ventilation. The total areas of the openings should not be less than the following: 8% of floor area, in case of dwelling rooms, 10 % of the floor area, in case of service spaces such as toilets, kitchens, bathrooms, stairwell or the likes.

The article also mentions that, except for kitchens of residential units, it is allowed to ventilate and light offices and service spaces artificially. However, in the cases of the hotels, hospitals and public spaces where artificial ventilation is not available, it is allowed to use a courtyard to ventilate and light the bathrooms and kitchens appended to the rooms. The specified courtyard must not be less than 1.5 square meters in area and the smallest dimension must not be less than 1 meter.</td><td>The study criticism according to this article, depends mainly that the article only enforce that every room should have a window, with fixing a minimum of 8% of the floor area and 10% in the case of service area. On the other side, the article neglects the orientation of the room and the location of the whole building, this makes the article very superficial.

The study also argued that, this part shows the complete negligence of environmental concerns. As the first priority is given to artificial lighting and air conditioning. Added to that, no reference has been given to keeping natural ventilation even as an option. Even when presenting natural ventilation and lighting, as a replacement for the artificial ones, the suggested solution is a 1.5sq.m court, which is basically a duct.

Controversially, the study also demonstrated that, the law excludes office buildings from abiding to the regulations it has specified for other types of buildings, although office buildings are used for long hours and must provide the same safety and health conditions for employees. Hence, the law represents HVAC systems and artificial lighting as the only ventilation and lighting solutions for office buildings.</td></tr>
<tr><td>Article 99</td><td>The article shows that, in the case of rooms or service areas where it’s impossible to open up windows that overlook courtyards or streets, it is allowed to make recessions (pocket court) in order to allow an opening. The depth of the recession must not exceed half its width and the window must be directly in the face of the recession. It is also allowed to build balconies in recessions, with a maximum width equal to half that of the recession.</td><td>The study demonstrated that, this article promotes the unhealthy conditions, in which the rooms are not ventilated well nor achieve the efficient daylighting. As the article suggests that buildings could be attached to each other and that the rooms which face the wall of the adjacent building may be ventilated and lighted by a pocket court which depth is at most half its width. Such pocket courts are usually 1.0x1.0m ducts that do provide neither healthy ventilation nor adequate lighting.</td></tr>
</table>

Table (6.1): Some of the deficiencies points in the current regulation which is the Unified Building Law
Source: (Ayyad & Gabr, 2012) Adapted by the author

According to the previous table, it was obvious that most of the regulations not relevant to the design principles of sustainability pratically the energy efficient configurations. Thus, this mainly proved that; there is a big need to reform the Unified Building Law at large scale in order to catch up with universal standards (Ayyad & Gabr, 2012). This meanly the role of the government, as it is widely known that; the governments can take the lead in crafting unique policies and implementing ways for reducing the energy consumption and the negative environmental impacts, as well as can initiate small changes that will lead to a more sustainable community (Romero, 2006).

On the other side, there is good news that; there are concrete steps today from the Housing and Building National Research Centre (HBRC) were put towards Sustainable Built Environment in Egypt. It was issued energy efficiency building codes in 2005 and the Green Pyramid Rating System for new construction was issued by a ministerial decree, in 2010 (HBRC, 2010). The Green Pyramid Rating System (GPRS) is defined as a national environmental rating system for buildings. The rating system is like any other rating system in the other nations, which provides definitive criteria by which the environmental credentials of buildings can be evaluated, as well as the buildings can be rated and certificated. It's worthwhile to mention that, the GPRS provides 4 levels of certifications depending on the score of the project in the weighted factors, among that certifications are the silver pyramid, gold pyramid and green pyramid. The negative aspect here that, GPRS documentation does not specify any timeline for its enforcement, although it described itself as legislation which need urgent application for its contents. This may be returned to the reason that, the GPRS was made as a project for a legislation that is still under analysis and public review (Ayyad & Gabr, 2012).

Add to the Green Pyramid Rating System, the Housing and Building Research Center (HBRC) of the Ministry of Housing has also developed the energy efficiency building codes for residential buildings. This residential energy code gives the minimum requirements to improve both thermal and visual comfort as well as the minimum energy efficiency requirements in both the non-conditioned and conditioned buildings. In addition to that, the developed code also gives minimum energy performance standards for buildings' detailed components and envelops (HBRC, 2010). The good point here is that; Egypt has reacted with efficient building codes. But the deficient point is that; the building codes seem to face the same end as other non-enforced rules and laws in Egypt. Thus, the main aim today is to concentrate the efforts to enforce the efficiency building codes in the construction of any new buildings (Ayyad & Gabr, 2012).

Moreover, there are energy efficiency standards and labels for household appliance. It is worthwhile to consider that, more standards and labels have been developed for the electric water heaters, the electronic ballasts and the compact fluorescent lamps. They have been approved by the Egyptian Organization of Standards in order to be issued through a ministerial decree. There are numerous barriers that negatively preventing their successful implementation. Among those aspects are; the lack of stakeholders and customers awareness and knowledge. In addition to the absence of a neutral accredited testing laboratory, as well as the verification of the efficacy and the enforcement of the standards and labelling program (HBRC, 2010).

On the other side, in the term of the renewable energy, it's worthwhile to mention that, thousands of cities and local governments around the world have activated their policies, plans and targets for renewable energy and climate mitigation (Sawin, 2012). Many communities set renewable energy targets for buildings, reformed building and altered permitting, as well as land-use policies to incorporate renewable energy requirements during the 2011 (Vidican, 2012). In the past, although energy efficiency had not taken a prominent role in Egypt’s energy strategy, the Egyptian’s energy strategic framework has adopted different measures to increase the role of rational use of renewable energy power generation. Nowadays, it's worth mentioning that, the renewable energy received more attention and reached a reasonable level of exploitation, as it lies under the responsibility of the Ministry of Electricity and Energy (MOEE). Add to that, the ministry also created a dedicated organization which is the New and Renewable Energy Authority (NREA) for the development of renewable energy national strategy and bearing the duty of its implementation. Even though, there are some barriers are affecting the development of renewable energy such as economic and financial barriers as well as the absence of well-defined legislation promoting renewable energy applications (Razavi, 2012).

To sum up it can be said that, Egypt has sufficient numbers of regulations, codes, standers and environmental institutions, but the problem lies in the efficiency, functioning and implementation of regulations. It's worthwhile to mention that, the Green Pyramid Rating System, nor the energy code, as well as the energy standards and labels were not designed to be in harmony with the Unified Building Law. As, there are a lot of contradictions between all of the documents and the law, add to that each document do not even mention that there is another code or rating system should be followed. For this reason, each one represents an isolated document that does not fit into the current legislations, nor represent a binding legislation on its own. Actually, there is a gap between a fully-enforced non-green building law and an unendorsed green building law, such as the Green Pyramid Rating System or energy codes. This gap must be filled to reach more environmental projects (Ayyad & Gabr, 2012). Over and above these elements, a process of implementation and enforcement of codes and labels is required, in which it starts by greening some of the regulations of the Unified Building Law and also by putting a timeline for the enforcement of the Green Pyramid Rating System that starts by giving incentives to projects that apply it. Then, the next step should be imposing punishment on the projects which do not use it and ends by requiring the achievement of at least a ‘GPRS-certified’ standard for gaining the license (HBRC, 2010).

Consequently, the Egyptian policy-makers should promote the concept of the energy efficiency regime, which depends mainly on the development of renewable energy, the efficient use of energy, as well as mobilize alliances between various groups to make renewable energy viable for the whole areas of Egypt (Razavi, 2012). Also, the government has arrived at the conclusion that, improving energy efficiency can be done by reducing quantities of energy consumed, changing processes and offering a powerful tool for achieving sustainable development. This development is characterized by clean environment and advanced technologies. The next recommendation is for policy action in several areas, in order to satisfy these needs. As, the Egyptian government should give high priority to a policy that promotes the development of new and renewable energy strategies and a technology roadmap, as well as expand the integration of the all sectors in this road map. Among those sectors are the education, training, employment, economic diversification, private sector development, as well as the building technological sectors (McCracken, 2004).

- Action plan:

Besides, the linking to the national objectives and vision, the sustainable energy and climate action plan must be clearly linked to the city's action plans. It's worth mentioning that, horizontal coordination among the strategies in various considered fields of the project should be controlled. Also, it is necessary to ensure that, a common vision and clear goals are agreed on across all the sectors (UN-HABITAT & UNEP, 2009). In Egypt, the wide scope for local action mainly depends on the role of the government to find ways of controlling and managing among the different responsible sectors and stakeholders (Bayoumi et, a.l., 2007). The following part discusses the role of the Egyptian government among those sectors.

1. Private Sector Involvement: It worthwhile to mention that, the projects initiated by the private sector can play an important role in mobilizing sustainability in urban development. The Egyptian government should encourage the private sector to undertake large scale development projects, this may be returned to the reason that, the Egyptian private sector is more successful than the public sector at planning and implementing. Thus, it is mainly the role of the government to encourage only the businesses that promote the city's sustainable goals, this can be done by applying a tax-free policy in order to attract them. Add to that, the private sector should also do great efforts to decrease their negative impacts on the environment, where they include minimization of pollution and sustainable use of natural resources.

2. Non-Government Organizations (NGOs): Those Organizations can be very effective agents for building public awareness at the local level, for environmental action plans and for voicing local concerns. However, environmental NGOs are focused exclusively on natural resource matters and global issues, as well as pay insufficient attention to an improper energy problem and other environmental health problems. The non-profit organization that fits into this category should include the professionals and sub-professionals which are working in specific disciplines such as energy efficiency, water supply and waste disposal. Besides, the membership should also include engineers, administrators and even support personnel with different grades of employment in the public and private sectors (UN-HABITAT & UNEP, 2009).

3. Media: It's worth mentioning that, the government should establish a new type of the media, which report concerns about the adverse impacts on the environment of the various developmental activities of man. Added to that, the news and updates on the environmental impacts can be transmitted via traditional media such as the newspaper, the radio, the television and the electronic media. Also, the environmental impacts can be transmitted through meetings and presentations with the communities in the given geographical area (UN-HABITAT & UNEP, 2009).

4. Public Participation: The core aims of participatory development planning are to give people a say in the development decisions that may affect them. Also, the main aim is to ensure that development interventions are appropriate to the needs and preferences of the population that they are intended to benefit. Participatory development planning can be undertaken by government agencies. Actually, there are numerous approaches that the agencies should consider them among their plans, such as the awareness-raising and mobilizing of communities as well as citizens to encourage them to get involved in development planning processes. Also, building the capacity of local level stakeholders to participate in these processes (McCracken, 2004).

5. Technical Sector: In this sector, the government should give recommendations and enforce the specialists to apply and integrate the principles of sustainability in designing houses. This can be done by well integrated the house with its surrounding environment, as well as used the climate conditions of the site to achieve the human comfort. The architects should take into consideration all the environmental passive design strategies while designing the house such as a proper selecting of windows, adequate insulation, daylighting principles, as well as applying efficient ventilation strategies (Liming, 2011). While the urban planners should help the local officials to solve the social, economic and environmental problems. They should recommend the best zoning areas in which new buildings are required to meet the standards of environmental efficiency (Baechler & Love, 2004). Added to that, the landscape architects who work on green building sites, they should apply their expertise to plan attractive sceneries and at the same times conserving water. To do this, they practice using local plants that require less water. They also might plan drainage channels to diffuse rainwater throughout planting beds (Liming, 2011). The last sector is the

workers, actually this one represents one of the main challenges for Egypt and other countries in the region. As there is no skills development strategy for environmental construction, so great efforts should be done to increase the workers' awareness about green construction (Bedrous, n.d.).

6. Educational system: It worthwhile to mention that, the government should improve the role of the educational and research organizations in the environmental and the energy sector in Egypt. Despite the efforts and projects which have taken place in Egypt in the field of green buildings, there are still a lot of research gaps and needs that ought to be covered in the near future. The approaches of a sustainable urbanism and the energy efficiency should be integrated in the curriculum of urban planner's educations and the architect's as well (Bedrous, n.d.) Besides that, the government also should improve and promote the awareness of the homeowners, in order to save energy in households and encourage the purchase and installation of energy efficient appliances (Thomas, 2003).

At the end, it was concluded that, the sustainable neighborhood's future is not just an aspiration, it is becoming reality around the world, in which the inhabitants, business sectors and government organizations change their lifestyle to meet the challenges of resource depletion. The master plan of sustainable neighborhood would need to offer integrated solutions in multiple challenges, including design and flexibility to integrate sustainability techniques. Such techniques should be changed into schemes that study the project as a whole, phase by phase starting from the design and planning phase, construction, implementation and ending from the final phase operation and management. Such approach has become the main approach to work towards a more sustainable and an environmental development in the last few decades. Hence, it is the time for Egypt to change the traditional used methods, as these traditional approaches were just schemes with no regard to future changes. Added to that, the government should solve all the problems that face the implementation with all means and methods. Moreover, the building regulations should also be strengthened to set the standards which help to achieve new sustainable neighborhoods, which promote better design of residential buildings according to higher environmental standards and apply the most out of new technologies and approaches.

6.3. Recommendations for Further Researches:

From these conclusions and reflections in the previous chapters, the research suggested the need for further researches in a number of fields that could not be covered within this study scope. These further researches can be reached to more accurate results as regard the following points:

1. More investigations and studies should be done to demonstrate the ability of developing the current regulations in order to promote the implementation of sustainable practice.
2. More studies also should be done to investigate the role of the government in putting the strategies which control the budget planning and provide the funding for the sustainable projects.
3. Also, studies should be done to investigate the effect of creating such model cities on its resident from the social aspect.
4. Besides, comparison between the projects done by the private sector and the public sector should be done to measure the effect of the environmentally friendly concepts in improving the economic side of the countries.
5. Further studies will be needed to demonstrate how to encourage the participation of all the sectors of the community, in order to determine community needs and identify the implementation of the new innovative and appropriate solutions.
6. Finally, more studies to investigate the role of strong political systems in order to make political, economic and social decisions.

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الملخص:

شهدت الفترة الأخيرة إتجاهات كثيرة للإهتمام بالمحافظة على سلامة البيئة من التلوث ومعالجة المشاكل الناجمة من سوء إستهلاك المصادر الطبيعية. لقد ظهرت هذه المشاكل نتيجة سوء إستهلاك الطاقة وإستخدام مواد ملوثة للبيئة، مما أثر بالسلب على صحة الإنسان وعلى النظام البيئى بشكل عام. لذلك، يهدف البحث إلى دراسة مؤشرات الإستدامة فى المجاورات السكنية الحديثة. حيث، يهدف إلى دراسة المعايير والمبادىء التصميمية التى تؤدى الى رسم صورة تقريبية للبيئة المعيشية المستدامة فى المجاورات السكنية.

ونظرا للكثافة السكانية المتزايدة التى شهدتها مصر فى الأونة الأخيرة، إتجهت الحكومة إلى إنشاء تجمعات عمرانية جديدة حول القاهرة لإستعاب هذه الكثافة المتزايدة. وحيث أن هذة التجمعات لا تطبق الأسس البيئية الصحيحة فى تصميم المجاورات السكنية، مما أدى ذلك إلى ظهور مشاكل بيئية كثيرة بشكل عام و سوء إستهلاك للطاقة بشكل خاص. وحيث أن، المبانى السكنية تأتى فى مقدمة المبانى التى تسهم بالنصب الأكبر لإستهلاك الطاقة ويتزايد إستهلاكها من المصادر التقليدية أكثر بمرور الزمن. فلذلك، يستنتج البحث المعايير التصميمية الصحيحة التى تؤثر بشكل مباشر على تصميم المجاورات السكنية ذات الكفاءة العالية فى إستغلال الطاقة. تلك المعايير قد تم إستنتاجها من خلال تحليل بعض الأمثلة الحديثة المشابهه، وتحليل المصادر العلمية المختلفة بهدف الوصول إلى حلول علمية وعملية وتطبيقية لمواجهة المشاكل التى تتعرض اليها التجمعات العمرانية الجديدة فى مصر.

ومن الجدير بالذكر، أن هذه الحلول قد تم إستخدامها لتقييم إحدى التجمعات العمرانية الجديدة وهى مدينة الرحاب، حيث أنها تمثل واحدة من أهم المشروعات السكنية الحديثة فى القاهرة الجديدة. ولقد أوضح من خلال التحليل، أن حالة الدراسة المختارة لا تتفق مع معظم المعايير التصميمية والحلول العملية التى تهدف إلى نقص التاثير السلبى على البيئة بشكل عام، ونقص إستهلاك الطاقة بشكل خاص. كذلك أوضح أثناء الدراسة، عدم و جود أداة لتقييم مدى تقدم أو تراجع المجاورات السكنية المستدامة فى مصر. هذا ما يؤكد على ضرورة تطوير المعايير التصميمية و تحديث القوانين التشريعية الحالية، بهدف وضع أسس ومعايير حديثة يمكن من خلالها تطبيق مفهوم الإستدامة بشكل صحيح و بطريقة عملية على المجاورات السكنية الحديثة التى تهدف إلى توفيرإستهلاك الطاقة والمحافظة على سلامة البيئة من التلوث. وأخيرا، يقترح البحث منهجية للوصول إلى بيئة معيشية مستدامة فى المجاورات السكنية ويدرس إمكانية تطبيقها على المجتمعات السكنية الجديدة فى مصر.

جامعة عين شـــــمس
كلية الهندســــــــة

الحلول البيئية كأحد المداخل الرئيسية للمجاورات المستدامة
دراسة حالة التجمعات الجديدة

رسالة مقدمة للحصول على درجة الماجستير في الهندسة المعمارية

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(٢٠١٤)

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دراسة حالة التجمعات الجديدة

رسالة مقدمة من

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تاريخ المناقشة : ../../...

الدراسات العليا

ختم الإجازة:

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موافقة مجلس الجامعة
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إقرار

هذه الرسالة مقدمة إلى جامعة عين شمس للحصول على درجة الماجستير في الهندسة المعمارية . إن العمل الذي تحويه هذه الرسالة قد تم إنجازه بمعرفة الباحث عام ٢٠١٤.

هذا ويقر الباحث أن العمل المقدم هو خلاصة بحثه الشخصي وأنه قد إتبع الإسلوب العلمي السليم في الإشارة إلى المواد المؤخوذه من المراجع العلمية كلٌ في مكانه في مختلف أجزاء الرسالة.

وهذا إقرار مني بذلك،،،

الباحث: سارة عبد الباقى محمود عبد الباقى حمزة

التوقيع:

التاريخ: / /٢٠١٤