Application of Design Thinking & Planning in New Cities to Manage Conserving Energies

Dr. Akram Farouk, Ain Shams U, Cairo, Egypt

ABSTRACT

Energy has become a crucial element that affects various aspects of daily life. In the process of design thinking and planning of new cities, energy conservation has become an important issue that can play a twofold role. The first one is to face the problem of the forecasted depletion of nonrenewable energy resources. The second one is to reduce the environmental pollution. The whole world started to develop new methods and systems in the design and planning process to create a new eco-friendly city. One of these systems and the most recognized one is "Leadership in energy and environmental design" (LEED). All these systems are made to keep pace with the new requirements of the future era, taking into account sustainable economic thinking and preserving a suitable life on the earth. It was found that with the expansion in the Arab republic of Egypt in the establishment of new cities, no regard was given towards energy conservation, so this paper is an attempt to apply design thinking & planning in the conservation management of energies in new targeted cities.

Keywords:

Egypt; Design Thinking; Planning of new cities; sustainability; LEED; Energy conservation.

Introduction

Arab republic of Egypt tends to solve the housing problem through horizontal expansion by invading the desert to accommodate the increasing population. Such projects help in solving the problem of unemployment by creating new work opportunities. The government began this trend in the late twentieth century to develop comprehensive plans and design strategies for the establishment of new cities. As a result to this expansion major problems were faced such as shortage of energy sources, rising costs and the increasing pollution resulting from the improper and increasing rates of consumption.

However all the planning schematics for the new cities didn't take into account the utilization of energy sources, rationalizing consumption and reducing pollution sources by applying administrative planning thinking to design cities that maintain the environment.

Many countries in the world started creating new cities that apply proper design thinking and planning to achieve lots of goals regarding energy rationalization and organizing energy usage systems. This ensures the elimination of pollution sources to preserve the environment. The main target is to create a suitable atmosphere to its inhabitants that commensurate with the requirements of modern life without the effects of pollution. This was accomplished through many examples such as (Masdar city) UAE.

What is green architecture?

Green architecture has become the future goal for most cities in the new world which seeks to provide a good environment for residents with an attempt to reduce energy consumption and reduce pollution.

Green or sustainable architecture can be defined as a structure that is environmentally responsible and resource-efficient throughout a building's life-cycle: from sitting to design, construction, operation, maintenance, renovation, and demolition. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort buildings. (1)
(fig. no. (1) indicates elements of sustainable architecture).

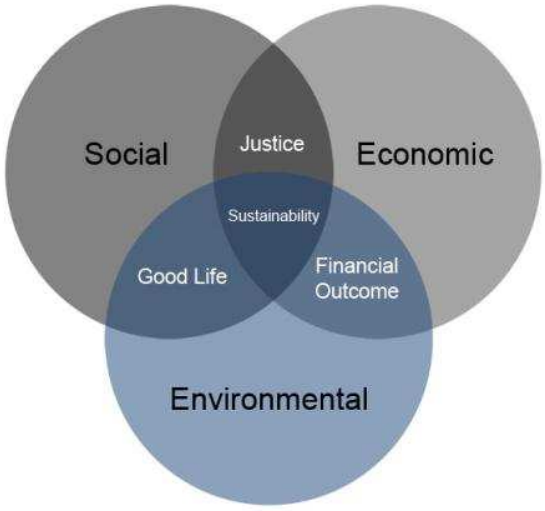

Fig.(1).indicating elements of sustainable architecture. (From Green Building Basic Information [1], 2009)

The main elements that must be dealt with in an appropriate manner for the building to achieve good environmental performance are:

- Surrounding environment.
- Energy consumption.
- Resources.
- Building economical impact (through initial & operation costing study).
- Direct impact on society (choosing the appropriate location for the building).
- All aspects related to water consumption.

Meeting the requirements of environmental performance regarding the previous elements and dealing with them in an appropriate manner by taking into account the following basics of green architecture:

- Using renewable energy technologies.
- Rationalization control of water consumption.
- Internal space air quality in addition to using natural ventilation.
- Utilizing natural lighting to decrease electrical energy consumption.
- Regulation of automatic HVAC operation systems at the times of maximum loads.
- Smart selections when it comes to choosing construction materials to minimize CO2 (Carbon Dioxide) emissions & to provide thermal comfort level which is appropriate for the users of buildings.

Into the Definition of the sustainable city:

The sustainable city is a city designed with consideration of environmental impact, inhabited by people dedicated to minimization of required inputs of energy, water and food, and waste output of heat, air

pollution and water pollution. As the existing problem in many cities is the absence of social, environmental, economic and urban harmony. Social harmony between the generations at the level of residents and homogeneity on the administrative level of the local administration to form a cultural identity that fits the community and the balance between self-interest and public interest.

Sustainable Planning & Design:

The world started recognizing the close link between planning new cities and the extent of its relationship with economic & environmental development. And that in order to avoid the exploitation of natural resources, and the waste and pollutants produced by the cities.
There must be good planning to the new cities by achieving (sustainable development) which can be given the expression of (meeting the needs of the present generations without compromising the ability of future generations to meet their needs in a good atmosphere and a suitable environment).

Most of the world countries in the last century have encountered a great interest in the matter of environmental protection and sustainable development; this was manifested in the trends towards establishing new cities compatible with the environmental elements to provide suitable living places. Consequently, all aspects of construction were affected by environmental issues in many countries all over the world. (2)

"Sustainability", "Green architecture" concepts in the construction sector:

Sustainable design, Green architecture, sustainable construction. All these concepts are new ways & methods to design and to construct buildings and cities that take into account environmental & economical challenges that face all sectors. Nowadays new buildings are designed & executed & operated by advanced methods & technologies that help in minimizing the environmental impact and in the same time help in decreasing the operation costs & maintenance costs. Also one of the most important contributions of sustainable design is providing safe & comfortable urban environment.
So the reasons to adopt the concept of sustainability in urban sector are not much of a difference than the reasons that lead to adopting the concept of (sustainable development) with all its environmental economical & social intersecting aspects.

According to some estimations building industry around the globe consumes about (40%) from the total used raw materials and that consumption is estimated to be around 3 billion tons annually, in the USA buildings consume (65%) from the total energy consumption of all kinds and causing (30%) of the (green house emissions), the importance of merging the applications & exercises of sustainable architecture is obvious & clear. Architect (James Wines) points out in his book "Green Architecture" that buildings consume 1/6 of world's supplies of fresh water, 1/4 of wood production, and 2/5 of fuel & fabricated materials in the same time producing half of the "Green house emissions".
And in addition to that the built environment in the world will double in a very short period varying between 20-40 years. And these facts make the operations of construction & operating new cities one of the most consuming industries in the world to energy & resources. Adding that the pollution caused by the inefficiency and waste of the buildings it is originally the result of bad design of buildings. (3)
Contaminants & residues that cause significant damage to the environment is nothing but results (by-products) to the way we design our buildings and methods of construction, operation and maintenance.

That's why (bio-systems) became unhealthy due to this contaminants that indicates the existence of unsafe environment for the users, so the green wave in the branch of urban design works on saving the environment and energy resources on the long run.

Sustainable urban strategy:

Sustainable urban strategy can be defined as a comprehensive strategy that takes into consideration and works on developing all aspects of the used systems in the city and that through the following:

1- Limiting the weather changes and protecting the layers of the atmosphere.
2- Using eco-friendly transportation means.
3- Minimizing the mistakes caused by the deterioration of public health.
4- A responsible management system for natural resources.
5- Preservation of the natural environmental variety which is embodied by the earth's environmental system. This is considered one of the continuous development pillars the human life depends on.
6- Upgrading the standards of life for humans.
7- Economic development which guarantees a production and consumption less polluting to the natural resources and less dangerous on the environment and life. And this requires a re-study in current methods of production and consumption. (4)

Sustainable urban planning:

- Sustainable land use planning.
- Location sustainable development.
- Building sustainable design. (5)

There are multiple elements in the sustainable urban planning on all aspects in new cities such as:

1. Conservation of empty land spaces outside the limits of the built area and designing close urban community compounds to achieve:

   - Minimizing the cost of constructing services & infrastructure and public buildings.
   - Minimizing pollution.
   - Creating stable societies.
   - Studying the benefits of land limitations.
   - Studying the geology & topography of the land to benefit from it in the stages of design & planning.

2. creating multiple uses urban communities and encouraging pedestrian movement to achieve:

   - Reduction in energy consumption.
   - Reduction in vehicle movement.
   - Reduction of sources of environmental pollution.
   - Increased green areas and pedestrian walking lanes helps decreasing exhaust emissions.
   - Studying land use proportions to decrease environmental pollutants.

3. Studying construction materials and methods to achieve:

   - Benefiting from special materials to maintain a good environment.
   - Studying construction materials that suit the city's primary target.
   - Benefiting from construction methods that can be used to reduce energies consumption in the building, and providing methods that don't need maintenance works or affect the public or the private environment.

4. Applying environmental provisions & standards on all design elements and new cities planning elements through providing some elements in the design process related to:

   - Gathering the residential units in one group.
   - Forming the residential compound.
   - Increasing the green areas & the environmental elements.
   - Studying how to benefit from suitable environmental materials.

5. Application of regulations & provisions that maintain the application of all standards including the following:

   - Protecting the green areas of special nature.
   - Providing a variety of urban communities to suit all users.
   - Preparation of recreational areas & parks with the application of all environmental standards to provide the appropriate environmental content.

6. Encouragement to develop sustainable planning & design thinking, development of planning & design thinking is encouraged in order to find a new city with a special environmental characteristics through:

   - Intellectually distinct design for the infrastructure to reduce cost and reduce sources of pollution.
   - Providing distinct zones in the stages of planning and integrate them together environmentally.
   - Preparation of studies for the conservation and utilization of available resources.
   - Rationalization of the consumed energy to provide methods that suit the nature of the project to reduce energy use or to re-employ them.

7. The preparation of the detailed integrated planning studies:

   - The achievement of a good planning project comes only through schematically managing the project and by studying all the various details to integrate them to achieve the required objectives.

8. Planning & design thinking management to conserve energy:

As the design thinking management is considered an important matter that must be studied because by applying it we can achieve new cities that complies with the demands of the current age. This can be achieved by:

- Design thinking management to achieve an environmental design which conserves energies and reduces the consumption and conserves the surrounding environment all these aspects when integrated together provides a good atmosphere that suits a prosperous life.
- Creating new design methods that suit the demands of our age.
- Providing all kinds of ways and systems to achieve an economical system that can achieve the required target through management.
- Redirecting design thinking management to benefit from similar experiences.

9. Smart growth planning management for the new cities, the planning of new cities must be applied to management systems through the following:

- Achieving the growth thinking to the urban compound in the city.
- Studying the dangers of urban growth and setting regulations to control them.
- Studying the usage elements and the development thinking for them.
- Applying sustainable environmental solutions. Where applying smart management systems in planning operations to guarantee achieving best expected outcome.

Planning design management development elements in new cities (6)

Planning design management in new cities can be developed through a group of elements as follows:

- Managing the location environmentally to find out the elements to benefit from in the design process.
- Design thinking management to create urban spaces suitable for the user's demands and to achieve general preservation to the environment.
- Achieving energy conservation systems and limiting pollutants in all the design elements.
- Benefiting from water management (especially) in all the stages of using it, plus achieving natural management to rain water.

Design thinking & planning in new cities stages

- Per-execution stage: (7)

  Which is considered one of the most important stages in design thinking & planning in new cities through the management of all project operations in the stage prior to implementation through site selection, applied systems to the whole for all the work selection, building materials & construction methods selection, and other design operations to achieve integration of design systems to design a new city that fits environmentally and economically (fig. no.(2) pre execution stage steps) with the demands of the users this age with the required efficiency and by maintaining energy & various resources while reducing pollution.

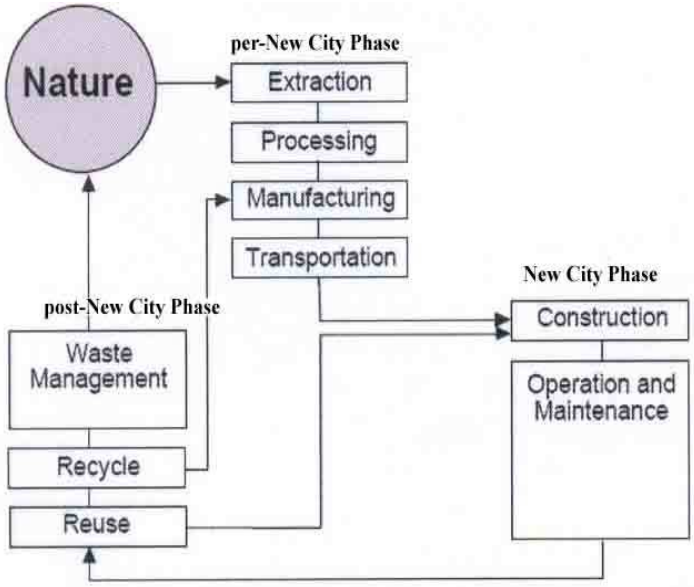

Fig. (2). Pre-execution stage steps. (From "Masdar City: Fast facts" [7], 2008)

- Execution stage in new cities

  Its importance comes from it's the stage that affects directly on the economical & environmental aspects, through proper management, implementation can be done with competencies and good practice in systems and good choice of materials to achieve the reduced impact on the environment.

Sustainable development elements in a building

1) Effective design in plans, where we can benefit from: (8)

   - Reducing house built area which leads to the reduction in the amount of used building material.
   - Saving resources and the costs of fabricating construction materials and reducing the negative effects to the fabrication process.
   - Reducing the costs of ventilation and air conditioning plus reducing maintenance costs.

2) Good building orientation for better natural lighting and ventilation, where we can benefit from:

   - Good building orientation is the least costing development work.
   - Providing a comfortable living inside the residence.

3) Using proper & sustainable building materials where we can benefit from:

   - Reducing building costs.
   - Finding alternative construction material.

- Reducing the waste resulting from the construction process.

4) Interior design that maintains good quality of internal air (fig. no. (3) shows using sunrays in natural lighting), where we can benefit from:

Fig. (3). shows using sunrays in natural lighting.
(From "LEED Projects Directory - Certified Project Directory" [8], 2008)

- Improving the health of the inhabitants, therefore reducing the economical waste.
- Reducing the dependency on mechanical systems to handle the indoor air which saves energy, therefore reducing the consumption of natural resources & reduces the harms to the environment.

5) Reducing the waste during construction operations and using construction materials effectively (fig. no. (4) shows using insulated construction materials to maintain indoor temperature), where we can benefit from:

Fig. (4). shows using insulated construction materials to maintain indoor temperature.
(From "LEED Projects Directory - Certified Project Directory" [8], 2008)

- Saving building materials costing.

- Reducing the cost of waste disposal.
- Improving the environmental standard.
- Increasing the capacity of landfills.

***Time stages in sustainable planning*:**

1. Pre-execution stage

   This stage includes, choice of location, building design choosing raw materials used in construction, choosing methods of construction and installation under sustainable design strategies and the tests of environmental impact resulting from the design & orientation and the impact on the urban design and used building materials.

2. Execution stage

   This stage includes the period when the building is constructed and operated, construction and execution methods are tested aiming to reduce the environmental impact on the consumption of different resources.

3. Post-execution stage

   This stage starts when the expected life time of building ends, in this stage materials & elements in the building turn to resources to other new building to be recycled or restored to the environment.

   The building environmental impact drops massively by using local construction materials instead of imported other materials of the same type to save wasted energy in transportation. (9)

Sustainable buildings in design stage:

Phase 1:

Setting the building location in the layout with the least possible side effects, taking into account good orientation for lighting & ventilation when laying down the building. And this step is considered the best practical step to get best results in saving energy.

The building location must be chosen in the scope of the surrounding services & buildings so that any point within the compound can be reached by pedestrians to reduce vehicles usage, taking into account the current infrastructure in place around the building to be re-configured & used.

Phase 2:

Efficiency in energy consumption through good thermal insulation, using energy-saving lighting & other electrical devices taking into account the environmental impact & operation cost over the building's life time.

Efficiency in water consumption in interior & exterior spaces by choosing suitable types of vegetation in the landscaping process, and in internal spaces by choosing environmental friendly low flow sanitary fixtures. (10)

Phase 3:

Natural lighting by letting sun light illuminate the internal spaces as much as possible, as the sun is considered the only free source for natural heating & lighting by using solar heaters which help greatly minimizing energy consumption.

Phase 4:

Indoor Environmental Quality (IEQ) means more concern with the contents of the indoor air and the pollutants it could carry and possible means of air purification.

Phase 5:

Using recycled construction materials, or recycling the remnants of the construction, and making the idea of using recycled materials an important target for futuristic industries.

Phase 6:

Using solar energy to produce heat & electricity as it's considered the best source of renewable energy used in the field; wind energy can also be used by placing the wind turbines in a strategic location in the field to generate electricity.

Leadership in Energy & Environmental Design (LEED)

Design & planning for new cities is based on many items, but (LEED)is considered to be the most important approach that must be studied to ensure that the city is keeping pace with the requirements of our age, to design a building that uses technologies & strategies to improve performance in specific fields concerning energy-saving, water rationalization, reduction of carbon dioxide emissions and increasing the environmental quality of the internal spaces and to reduce the environmental impact of building on the surrounding space.

(LEED) application elements:

The LEED system application elements consist of the following:

1. Design & implementation of green building.
2. Interior design & implementation.
3. Green building operations & maintenance works.
4. Designing green residential neighborhood.
5. Design elements of residential building & their implementation.

6. Elements of the new city & taking into account the environmental elements in their design & implementation.
7. Study of new cities networks and their relevance for the environmental elements. (11)

Examples for new cities:

There are many examples for new cities where designers and planners try to achieve the abovementioned considerations in the following cities:

Biometropolis near Mexico City:

The city is designed on 71 hectares of land. It lays to the south of Mexico City. It is designed to contain a medical center, care facilities, teaching spaces, research institutions and laboratories.

Also the campus will include offices, apartments, shops and amenities to create a sustainable and a mixed use community.

The environmental solutions include cooling courtyards and the buildings will be oriented to capture cooling wind coming from the north.

Finally the campus is designed to maintain the proportion of green space through which water can be absorbed naturally. (12)

(Fig. no. (5) Shows the master plan of the City) (Fig. no. (6) Shows the perspective view of the city).

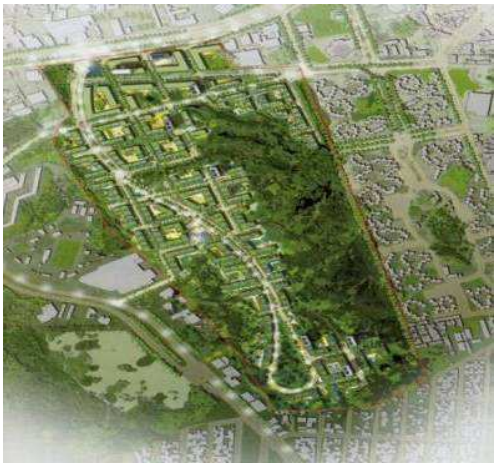

Fig. (5). Shows the master plan of the Biometropolis City
(From worldarechitecturenews.com [12]. 2009)

Fig. (6). Shows the perspective view of the Biometropolis city
(From worldarechitecturenews.com [12]. 2009)

Dongtan City in China:

The design process started in 2005, with the target to create an eco-friendly city in china which would exclusively use sustainable energy. The city will reduce energy consumption by 66% in relation to its neighbor shanghai. It is planned to provide housing for 500,000 people on 8,400 hectare near shanghai city.
Energy production in Dongtan city will depend on solar panels, wind turbines and biomass based fuels. Most buildings will have photovoltaic cell arrays on their roofs making most of the buildings in the city zero-energy or passive structures.
Roof gardens will be used to provide insulation and rainwater filtration.
Natural ventilation will be adapted through good building orientation, and buildings will have thermal glass to minimize the need for heating.

Reasons for designing Dongtan city:

By year 2020 China will need to provide housing in 400 cities for 300 million people from rural areas. This means a massive increase in energy consumption. So they will need to focus more sharply on energy efficient design, technology and the quality of urban planning strategies. (13)
(Fig. no. (7) Shows the perspective view of the city) (Fig. no. (8) Shows the lake part of the city).

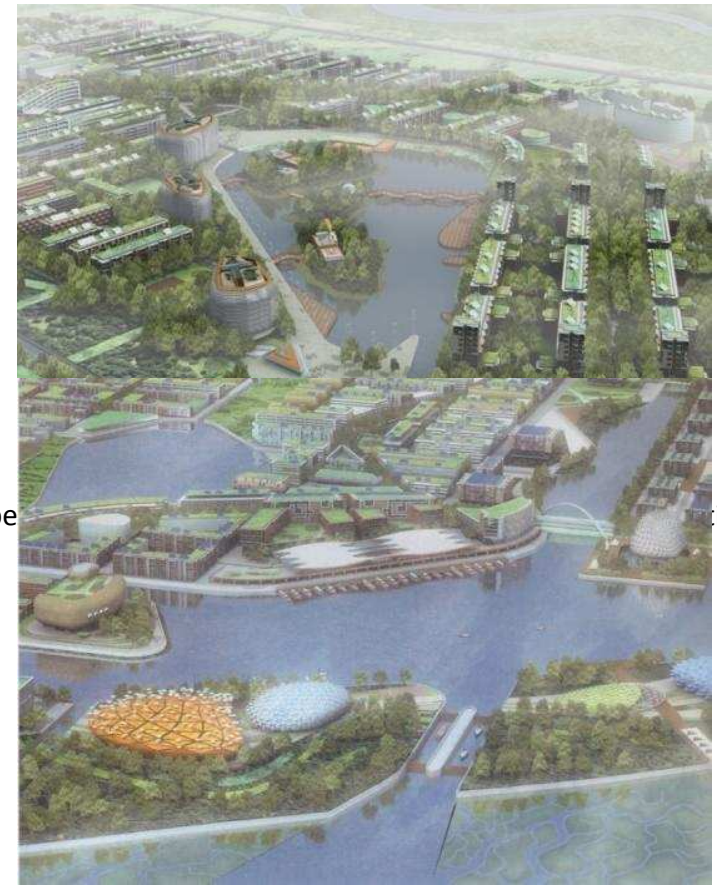

Fig. (7). Shows the pe ies.dk [13], 2010)

Fig. (8). Shows the lake part of the Dongtan city (From Sustainablecities.dk [13], 2010)

Greensburg city:

Following a devastating tornado there in 2007, the tiny city of Greensburg, Kansas has engaged in a sustainability-oriented recovery process through which it hopes to serve as a model for other communities planning for a sustainable future.

The city is being rebuilt on a master plan that relies on 4 sustainable opportunities:

- Recycling debris and spur rebuilding by making lots available to developers.
- Prioritize use of land for energy efficiency and natural / renewable materials development.
- Provide information and resources on types of buildings and sustainable designs.
- Work with financing agencies to include funding in the development for energy efficient construction

The city also set a positive example in passing a resolution that requires all publicly funded municipal buildings larger than 4,000 sq ft. to be built to "Platinum" certification standard, which is the highest certification level in (LEED) program.

Why sustainability in Greensburg:

The city of Greensburg could have been rebuilt in a way that replicated its past as many communities that recover from disasters do exactly this. But when the new master plan was designed, the planner had in mind the following:

- When rebuilding with energy conservation as a focus it was a response to the pressed worry shared by most Greensburg citizens – that they can afford the cost of a new home.
- The residents of Greensburg have always been going "green" as they are used to live in rural areas. This is nothing new to the original inhabitants. It's about bringing new technologies to the values and life style.
- After the tornado, 90-95% of the city was destroyed. So the city had a rare "start - from – scratch" opportunity to remake Greensburg's built environment. (14)
- (Fig. no. (9) Shows the master plan of the City).

- (Fig. no. (10) Shows Greensburg's Nearly-completed LEED Platinum City Hall).

Fig. (9). Shows the master plan of Greensburg city. (From Stacey Swearingen White. [14] Jul. 20, 2010)

Fig. (10). Greensburg's Nearly-completed LEED Platinum City Hall (From Stacey Swearingen White. [14] Jul. 20, 2010)

Masdar City in UAE

Masdar city is one of the most famous green cities. It is located in the UAE, and its construction is ongoing nowadays. (Fig. no. (11) Shows the layout of "Masdar" city). (15)

Fig.(11). Shows the layout of “Masdar” city. (From "Masdar plan" - The Economist. [15] 2008-12-04)

Masdar city is the first carbon free & waste free city in the world, also it’s the first complete city to make use of solar energy. (Fig. no.(12,13) shows covering the city center with shades that open during the day to absorb energy & provide shade and close during the night and provide energy for lighting), this came within a very promising initiative called “life on one planet”.

Fig. (12). shows covering the city center with shades that open during the day to absorb energy.
(From "Masdar plan" - The Economist. [15] 2008-12-04)

Fig. (13). provide shade and close during the night and provide energy for lighting.
(From "Masdar plan" - The Economist. [15] 2008-12-04)

Masdar is located near Abu Dhabi International Airport, United Arab Emirates is considered the first Arab city to apply energy maintaining systems in their design and implementation and through the application of the following: (16)

- General project planning.
- City center design with the gigantic moving shades inspired by the sun flower to provide shade to piazzas and public places in the city center.

Sustainability in "Masdar" city:

"Masdar" city will need about 200 mega watts of clean energy compared with more than 800 mega watts for a traditional city with the same size, the city requires around 8,000 cubic meters of desalinated water per day compared with more than 20,000 cubic meters per day for a traditional same-size city, 30% of Masdar city total area will be allocated for residential uses, 24% for business & research, 13% for commercial projects including light industry, 6% for Masdar institute of science & technology, 19% for services & transportation and 8% for civil & cultural rights events.

Design thinking & planning in "Masdar" city: (17)

Although the weather in "Masdar" city is very hot, but can be characterized as sunny and that's what the city architects used as the largest source of energy. Electrical power plant will be built that depends mainly on solar energy. The city also will be free from skyscrapers; building roofs will be covered with solar panels (photovoltaic arrays) a desalination plant to provide fresh water to the city, the city will also use a hydrogen powered station to generate energy as an alternative source for energy generation where the percentage of carbon dioxide emissions is much less than any other fossil fuel, (fig. no. (14, 15) shows cross sections demonstrating how water flows to underground water tanks).

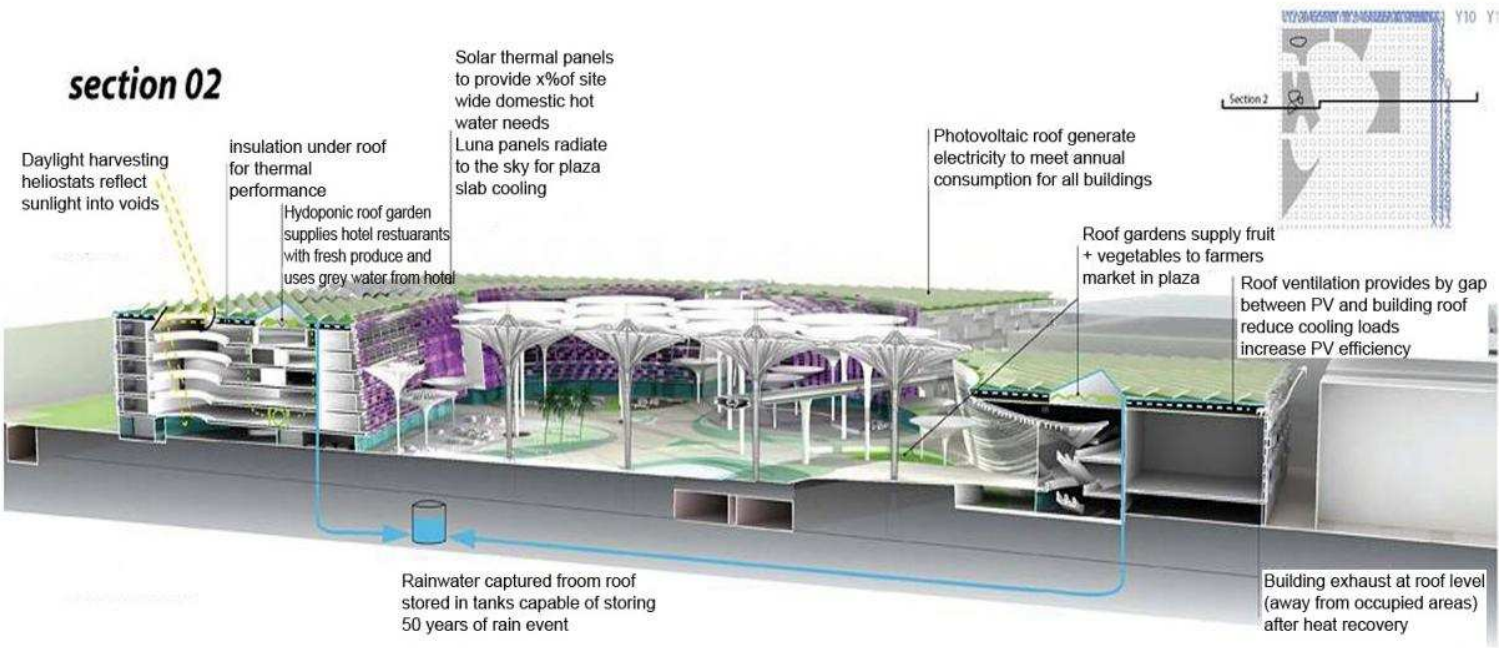

Fig. (14). shows cross sections demonstrating water flows to underground water tanks.
(From ASK magazine issue no.(9) [18]. March 2010)

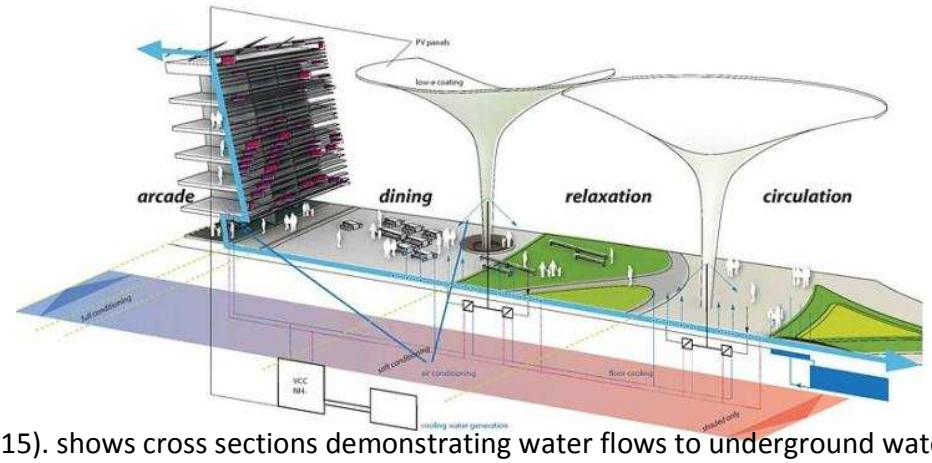

Fig. (15). shows cross sections demonstrating water flows to underground water tanks.
(From ASK magazine issue no.(9) [18]. March 2010)

A Carbon free city in Libya

Shahat Garden City - Madinat Hadaek Shahat - is located in the renowned Green Mountain region in eastern Libya, only a few kilometers south of the UNESCO World Heritage Site of the ancient city of Cyrene.
The new, mixed-use development will create homes for 60,000 people over the 1500-hectare site. The site offers some special conditions that give the opportunity to create a master plan design for low carbon living through walk-able neighborhoods, shaded streets, natural cooling and low energy buildings, wind farms and solar power fields, resulting in a significantly improved urban environment and a highly desirable place to live. (19)

These special conditions can be summarized in the following:

- The region has proven the need for heat insulated buildings due to the shift between daytime and nighttime temperatures due to its elevation of sea level.
- Also the terrain is good with agricultural land in comparison to the dominant terrain of Libya which consists mainly of desert.
- The site also contains many archeological sites that need to be studied in the city's master plan in order to be preserved.

The scheme aims to set new standards for building design and public space in Libya without compromising privacy and cultural imperatives.

(fig. no. (16) Shows the general view of buildings in the city). (fig. no. (17) Shows Shahat garden city master plan)

Fig. (16). Shows the general view of buildings in the city

Fig. (17). Shows the city's Master plan

(From www.tripolipost.com/articledetail.asp?c=2&i=4921 [19] 21/09/2010)

Conclusion & recommendations

It is clear from the foregoing discussion that there are many recommendations and conclusions in order to design & plan new cities with thinking that goes hand in hand with the demands of our age in the light of shortage in energy resources, while maintaining the environmental content and reducing pollution. This can be achieved through the following:

1. On design & planning level

- Application of standards & provisions of design & planning of new targeted cities elements in the governmental plan, plus attempting to restudy cities under implementation to overcome what can be changed to modify the course of some systems.
- Actions should be taken to preserve energies and to introduce helping means to achieve this.
- Trying to preserve our energy resources by thinking and developing new methods & systems, to achieve this by obligating designers & planners to standards & provisions in the design stage.

2. On the governmental level

- The need to change the general thinking related to the future expansions & extensions in new cities in the country.
- Striving to provide new cities that cope with the requirements of our age, achieving energy saving standards & environmental content.

- Activating laws related to fighting pollution inside cities on all levels.
- Applying systems that maintain natural resource & energies.
- The need for partnership between local administrations and residents in the decision making in the various phases of the project (From start to end)
- Good organization in the projects departments that must take into account the coordination between the relations on various levels, which interfere in the development decision making
- Horizontal coordination among the strategies in various considered fields of the project.
- Project evaluation by commonly agreed and defined means at the beginning of the project.

As a result it was necessary to change the traditional used methods in urban planning. As the traditional organizational schemes were just land uses schemes with no regard to urban development or future changes.
Such methods should be changed into a comprehensive urban development schemes that study the project as a whole, phase by phase starting from the design and planning phase, construction & implementation and the final phase operation and management. In addition to applying all environmental, economic and social concepts on the project site. And try to solve all the problems that face the implementation with all means and methods.

References:

1. U.S. Environmental Protection Agency. (Oct. 28, 2009). Green Building Basic Information.
2. www.buildinggreen.com.
3. James Wines, (2000). Green Architecture.
4. BURGESS RodCarmona MariaKolst. (1997). The challenge of sustainable cities.
5. Hope, Bradley; Stanton, Chris (2009-02-09). "Al Jaber secures Masdar deal". The National. http://www.thenational.ae/article/20090209/BUSINESS/779661070. Retrieved 2009-06-11.
6. "The Masdar Initiative: Introduction". MasdarUAE.com. http://www.masdaruae.com/en/Menu/index.aspx?MenuID=42&CatID=12&mnu=Cat. Retrieved 2009-06-09.
7. "Masdar City: Fast facts". MEED. 2008-02-17. http://www.meed.com/feature/fast_facts/2008/02/masdar_city_fast_facts.html. Retrieved 2008-05-10.
8. "LEED Projects Directory - Certified Project Directory". US Green Building Council. http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx. Retrieved 20 November 2008.
9. "LEEDv3". US Green Building Council. http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1970. Retrieved 20 February 2010.
10. Burr, Andrew C. (April 23, 2008). "LEED's Big Market Bias". Co Star Group. http://www.costar.com/News/Article.aspx?id=652024CBB8139C748C5F6F871CD4EF6B. Retrieved 2008-04-27.

11. “LEED Update December 2009”. US Green Building Council. Retrieved 5 March 2010.
12. http://www.worldarchitecturenews.com/index.php?fuseaction=wanappln.projectview&upload_id=12959 (Dec. 10, 2009).
13. Sustainablecities.dk/en/cityprojects/cases/dongtan-the-world-s-first-large-scale-eco-city
14. Stacey Swearingen White. (Jul. 20, 2010). Out of the rubble and towards a sustainable future: The “Greening” of Greensburg, Kansas. Sustainability journals.
15. "Masdar plan". The Economist. 2008-12-04. http://www.economist.com/science/tq/displaystory.cfm?story_id=12673433. Retrieved 2009-06-09.
16. www.sustainableschools.dgs.ca.gov.
17. www.masdar.com.
18. Nader Ramadan. ASK Magazine, issue no.(9) march 2010.
19. www.tripolipost.com/articledetail.asp?c=2&i=4921 (21/09/2010).

Acknowledgment:
This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.