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Energy Efficiency Strategies in Urban Planning of Cites

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Urbanization is the leading sector humans are working on where the ever-growing population is spreading globally, and constantly moving into cities. The major urbanization activities are taking place in the developing world. Consequently sensitivity to environmental issues related to energy, efficiency and sustainability become a vital issue when addressing urbanization. Although many countries of the developed world have given considerable attention to this issue, most developing countries have paid little or none attention. This paper is addressing this issue with special focusing on the Arabian Gulf area, where the rising prices of oil are having their impact on the booming construction sector. Moreover, the study investigates how existing cities are planned considering energy efficiency in much older cities as those in Egypt. The paper studies the relationship between cities and energy consumption in order to identify the factors having the most impact in planning for energy efficiency. Various factors are explored starting with the macro level; studying the city in relation to its surrounding region, its role, and size. Then the micro level concerning the city is studied including: urban patterns (compact vs. dispersed developments), land use distribution and home-work trip, road networks and transportation network, buildings with their layout forms, heights and facades treatments, and the use of renewable energy. In addition, the impact of city consumption in the form of its ecological footprint and sustainability are studied. The paper studies the role of legislations and laws addressing environmental issues and governance issues for energy efficient cities. It emphasizes the importance of communication between different stakeholders involved in the city. The paper presents a number of case studies situated in the Middle East as examples of the developing and transforming countries. First, the Gulf area which is now benefiting from the rising prices of oil and undertaking a huge construction movement. More and more money is poured in huge development projects raising a debate whether to follow the western pattern of growth or to return to the traditional compact cities. A different initiative for zero waste is the city of Masdar, United Arab Emirates is reviewed. Second, Egypt is presented as an example of much older urban settlements, undergoing continuous expansion to accommodate the flooding numbers seeking urban paradise. The ongoing program of strategic planning for cities, administered by the General Organization of Physical Planning GOPP, is studied to see how the program's terms of reference addresses the issue of energy efficiency. Moreover, the paper investigates whether this issue is tackled during the various stages of the planning process, or by any of the participating stakeholders or not. The other case study from Egypt is Cairo which is continuously expanding in all directions with different patterns of growth. The paper attempts to study how this growth relates to energy efficiency strategies. The paper concludes with a group of strategies for energy efficiency that could be implemented in the Egyptian context regarding new or existing cities in the context of building an overhaul vision for urban growth sensitive to energy efficiency.

I. Introduction: Urbanization in the Developing World

In 2005, the world's urban population was 3.17 billion out of a total of 6.45 billion. The year 2007 marks a watershed in human history, when for the first time more people will live in cities than the countryside, according to predictions by the United Nations. By 2030, over 60% of people will live in cities.[1] This rapid urbanization is particularly taking place in cities of the developing world.

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Over the past 50 years, cities have expanded into the land around them at a rapid rate. Highways and transport systems have been built in tandem to support this physical growth. Valuable farmland has been eaten up and car dependency has increased. Urban populations are expected to grow by another 2 billion people over the next three decades, and it is expected that cities in developing countries will absorb 95 percent of this increase.

UN-HABITAT's State of the World's Cities Report for 2006/7 points out the fact, that in many cases, urban growth will become synonymous with slum formation. Already, Asia is home to more than half of the world's slum population (581 million) followed by sub-Saharan Africa (199 million) and Latin America and the Caribbean (134 million).[2] Cities and urban settlements must be prepared to meet this challenge. To avoid being victims of their own success, cities must search for ways in which to develop sustainably.

A successful city must balance social, economic and environmental needs: it has to respond to pressure from all sides. It should offer investors security, infrastructure (including water and energy) and efficiency. It should also put the needs of its citizens at the forefront of all its planning activities. It recognizes its natural assets, its citizens and its environment and builds on these to ensure the best possible returns.

Modern cities are products of fossil fuel technology – most of the world's energy is used by cities themselves, and by the farming, industrial production and transport systems that supply them. Modern urban living crucially depends on uninterrupted energy supplies. The world's major transport systems start and end in cities. They are the nodes from which mobility emanates, with low transport costs having rendered distances irrelevant, plugging cities into an increasingly global hinterland.[3]

As world populations grow, many faster than the average 2%, the need for more and more energy is exacerbated (Figure 1). The world's energy consumption today is estimated to 22 billion kWhyr^{-1}, 53 billion kWh by 2020. Such ever-increasing demand could place significant strain on the current energy infrastructure and potentially damage world environmental health by CO, CO_2, SO_2, NO_x effluent gas emissions and global warming. Achieving solutions to environmental problems that we face today requires long-term potential actions for sustainable development. Enhanced lifestyle and energy demand rise together and the wealthy industrialized economics, which contain 25% of the world's population, consume 75% of the world's energy supply. The world's energy consumption today (22 billion kWhyr^{-1}) releases about 6.6 billion metric tons carbon equivalent of greenhouse gas (GHG) emission in the atmosphere to meet this energy demand. (Bos, E. etal. 1994) [4] GHGs emissions and energy demand have risen high on the global environmental agenda - particularly with the Kyoto Protocol and other related global agreements. Consequently an urgent need for the incorporation of energy efficiency issues to be included in urban planning and construction has risen.[5] To meet the urban challenges of today, and the challenges to come, appropriate planning strategies and management frameworks must be available, through which cities can apply innovative approaches suitable for their local circumstances. This paper will review the challenges that face the city and factors that affect new strategies for urban planning, where energy efficiency is the core issue shaping the city's future.

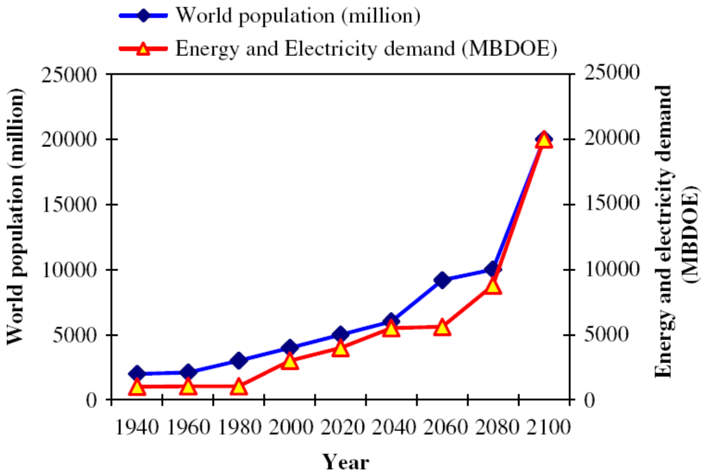

Figure 1 Annual and estimated world population and energy demand. Million of barrels per day of oil equivalent (MBDOE).[4]

II. Cities and Energy Consumption: The Macro Level

The city can be seen as an ecosystem comprised of 5 main subsystems that interact together. These are population sector, employment sector, housing sector, transport sector, and urban land sector. The interactions/ casual effective relationships between them can be seen in Figure 2.[6]

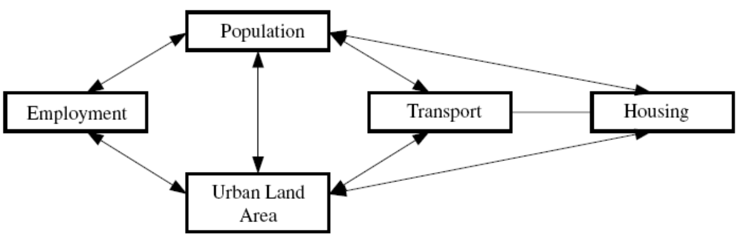

Figure 2 Casual - effective diagram at macro level

A. Size:

Cities vary in size starting from only 25000 inhabitants as the number of city dwellers specified by the General Organization of Physical Planning (GOPP) in Egypt. Having the population size as the main driving force of urbanization and the quest for fulfilling their needs in urban contexts is apparent from Figure 2. There is another dimension concerning the population pressure on urban contexts. This growing size of the city ultimately is leading to climatic change. This is only a part in the environmental chain of energy use, ozone depletion, desertification and biodiversity loss, as shown in Figure 3.[7]

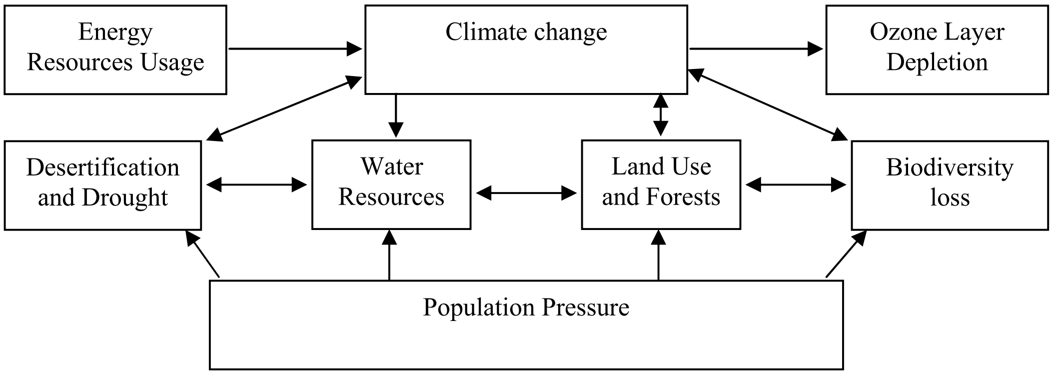

Figure 3 Relationships between desertification, climate change and biodiversity

1. *Mega growth mega complexity:*

The megacity is a relatively new form of urban development. In 1950, there were only two cities with populations of over 10 million: New York and Tokyo. By 1975, two more locations, Shanghai and Mexico City, joined the club. But by 2004, the number of megacities had rocketed to 22 and, together, these cities now account for 9% of the world's urban population. It is important to note that:

- ■ Mega cities' importance in the national and global economy is disproportionately high.
- ■ City governance has to adapt to the challenge of delivering holistic solutions across vast metropolitan regions.
- ■ City managers must strike the balance between three overriding concerns: economic competitiveness, environment and quality of life for urban residents.

Urban growth is spread unequally around the world, and the same is true of its largest cities. Most of the megacities in the developed world are growing slowly, if at all. Tokyo remains the largest with 35 million inhabitants, but the fastest growth will be in the developing world (particularly in Asia and Africa), placing huge pressure on infrastructure in those locations. By 2020 Mumbai, Delhi, Mexico City, São Paulo, Dhaka, Jakarta and Lagos will each have populations of over 20 million. For many emerging cities, soaring populations are extremely difficult to manage: at current rates of growth, the number of inhabitants in Nigeria's Lagos will double by 2020, mainly through expansion of informal settlements. By contrast, most mature cities (as well as many Transitional ones) will need to address a different kind of demographic challenge in the form of population ageing.

There is a continuous debate about megacities. On one level, these super-sized cities are seen as the engines of the global economy, efficiently connecting the flow of goods, people, culture and knowledge. They offer, at least potentially, unprecedented concentrations of skills and technical resources that can bring increased wealth and improved quality of life to vast numbers of people. However, megacities also conjure up an altogether darker vision. Most cities in the developing world were found to face huge challenges ranging from congestion and pollution to security threats and inadequate services groaning under the weight of excessive demand. Those in the developing world also struggle to cope with the rapid growth of informal settlements. Today almost one in three of the world's urban population lives in slums, without access to good housing or basic services.[2]

Today's megacities are not only bigger than the cities of the mid-20th century, they are also more complex. For one, they are increasingly competing with, and dependent on, relationships with other cities in the global economy. At the same time, we are witnessing the emergence of new city regions —sprawling conurbations that extend far beyond the boundaries of a single city. Examples include the "BosWash stretch" (extending from Boston, MA to Washington, DC) in the US, and Chongqing in China. These huge megacity regions create a new urban dynamic. Commuters travel large distances from densely populated suburbs. Economic activity frequently becomes deconcentrated, dissipating from the center to the periphery. Often fragmented systems of metropolitan governance have not caught up with this trend, with the result that it is difficult to deliver an efficient, holistic approach to infrastructure challenges at a metro regional level.[1]

B. Role and competitiveness

In the context of continuous globalization, cities put a lot of concern over its competitiveness to attract investments for its prosperity. In this quest, there is a struggle between economic competitiveness and employment, environment, and quality of life.

Megacities prioritize economic competitiveness and employment. When asked in a study conducted among 25 megacities all over the world, which issues drive decision-making, 81% of stakeholders involved in city management cite the importance of the economy and employment. There is a strong focus on creating jobs, with unemployment emerging as the top economic challenge for survey respondents from Emerging and Transitional cities. Competitiveness in the global economy is another important consideration. Six in ten stakeholders think that their cities place a high importance on making themselves competitive to attract private investment when deciding on infrastructure issues.[1]

Despite of this inclination towards economic competitiveness, where development decisions are often seen in terms of difficult trade-offs between growth and greenness, or growth and quality of life. There are obvious interdependencies between the three concerns. Competitive cities are more likely to have the wealth and resources to invest in high-quality infrastructure and services, and to create economic and social opportunities for large numbers of the urban population. All things being equal, environmentally clean, modern cities create more attractive locations for a broad spectrum of business activities than those with heavy pollution. Equally, cities with a healthy, well-educated urban population are better positioned to attract investment than those where deprivation and inequality blocks large portion of the population from participating in economic growth. This suggests that, in the long run, focusing on one of these concerns to the detriment of the others will be a recipe for failure as shown in Figure 4. [1]

Therefore cities need modern, efficient infrastructures, especially transportation networks. Abundant (and preferably skilled) labor together with modern IT and communications technologies are also hugely important, as evidenced by the offshoring trend that has itself fuelled the growth of cities like Bangalore in India. Another crucial factor is the quality of basic services: people with access to quality housing, education and good basic services such as water and electricity are much more likely to fulfill their potential and contribute to economic growth. The wider business environment is also a key factor: research from the Economist Intelligence Unit indicates that clear, business-friendly policies and regulations is a more important factor in attracting international investment than incentives such as subsidies and tax breaks.[1]

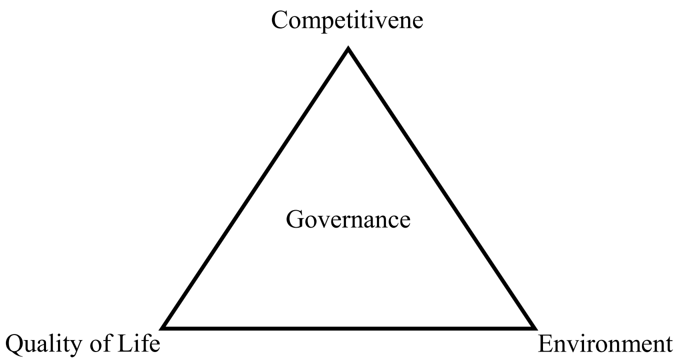

Figure 4 Striking a balance between these 3 aspects should be the main concern of mega cities governance

Whatever their potentials, however, many of today's megacities feature a catalogue of environmental problems. Congestion, air and water pollution, waste management and degradation of green areas are familiar issues in most large cities around the world, and are particularly extreme in the megacities of the developing world. There are also huge inequalities in the distribution of wealth and economic opportunity among the city. In its recent report on urbanization trends, UN-HABITAT describes cities as "the new locus of poverty". World Bank estimates predict that while rural areas are currently home to a majority of the world's poor, by 2035 cities will become the predominant locations of poverty.[1]

The consequences of a failure to improve quality of life for the urban poor are huge. The UN-HABITAT research indicates that people living in slums, where a large proportion of the urban poor reside, are more likely to be affected by child mortality and acute respiratory illnesses and water-borne diseases than their non-slum counterparts. They are also more likely to live near hazardous locations, making them more vulnerable to natural disasters such as floods. Inadequate access to basic services saddles them "with heavy health and social burdens, which ultimately affect their productivity".[2] Poverty may be less extreme in the more developed cities, but social problems still abound.

Historically, cities tend to get rich first and then clean up later. Unfortunately that approach could be disastrous in the context of climate change: this is one reason for the growing focus on sustainable urban development.

Sustainable solutions promote greater use of alternative energy sources and more energy-efficient buildings and transport, measures to combat congestion and CO_2 emissions, water and waste recycling, and the use of vegetation to filter pollution and capture carbon dioxide. While several cities have started implementing at least some of these measures to good effect, there will be a need for more concerted efforts if the environmental cost of urbanization is to be reduced.

Consequently, it is not growth and economic prosperity that cities should seek; it is rather a more sustainable development that combines efficiency, accountability and environmental responsiveness; a goal which comprises the main core of the Sustainable Cities Programme (SCP). This is a world-wide technical cooperation activity of the United Nations. It works at city level in collaboration with local partners to strengthen their capabilities for environmental planning and management (EPM). Each city-level SCP project is adapted to the particular needs, priorities, and circumstances of that city; nonetheless, all SCP city projects follow the same general approach and all are implemented through the same series of activities known as the SCP Process.[8]

The SCP recognizes that environmental deterioration is not inevitable. Although many, perhaps even most, cities are still suffering severe environmental and economic damage, there are encouraging signs. Some cities are learning how to better plan and more effectively manage the process of urban development, avoiding or alleviating environmental problems while realizing the positive potentials of city growth and change. The SCP aims to support cities in finding - and managing - development paths which are more effectively fitted to their environmental opportunities and constraints.

There is a common approach which is shared by all SCP cities and which holds true across the full, range of partner cities:[8]

- Central focus on development-environment interactions;
- Broad-based participation by public, private and community groups;
- Concern for inter-sectoral and inter-organizational aspects;
- Reliance on bottom-up and demand-led responses;
- Focus on process: problem-solving and getting things done;
- Emphasis on local capacity-building.

III. Cities and Energy Consumption: The micro level

Within planning research, it is commonly assumed that the design and location of residential areas have important consequences for households' consumption of energy for housing and transport. It is believed that physical planning and design make it possible to achieve a more sustainable consumption pattern.

Mainly there are four distinct consumption categories: energy use for cooling/heating and operating the house; energy use for everyday travel; energy use for long leisure-time travel by plane; and, energy use for long leisure-time travel by car.

A. Urban Pattern

In their study on relationship between urban planning and energy consumption Holden and Norland pose the question: does the change of urban forms tend to reduce the frequency and length of journeys, and hence energy consumption? To this day, the disagreement persists and the critiques against planning have many different forms, including:[9]

— Claims that engine technology, taxes on gasoline and driving, and road pricing, are more effective measures for reducing energy consumption than urban planning. (Gordon and Richardson, 1989; Boarnet and Crane, 2001)

— The assertion that socioeconomic and attitudinal characteristics of people are far more important determinants of travel behavior than urban form. Critics taking this position assert that the importance of form is highly overestimated in empirical studies. (Stead et al., 2000)

— Casting doubt on the assumption that proximity to everyday services and workplace will contribute to reduced travel in a highly mobile society. (Owens, 1992; Simmonds and Coombe, 2000)

— That the relationship between non-work travel, especially long leisure-time travel, and urban form has been neglected. (Titheridge et al., 2000)

— The assertion that travel preferences rather than urban form influence travel behavior: people live in city centers because they prefer to travel less, and not that they travel less because they live in city centers (the 'self-selection bias'). (Boarnet and Crane, 2001)

Even though these aspects should not be taken lightly, there seems to be overwhelming support in the literature for the idea that planning does matter in determining the level of energy consumption in urban areas. This view is based on both theory and empirical studies. Thus planning is an important instrument for promoting sustainable development.

1. Compact Vs Dispersed development

When it comes to land use characteristics that influence energy use for everyday transport, Næss (1997) concludes that the following characteristics are favorable for reducing energy use per capita: high population density for the city as a whole; high density within each residential area; centralized settlement within cities and towns (i.e. higher density in the inner part than on the fringe); centralized workplace location; low parking capacity at workplaces; decentralized concentration at the regional level; and, a high population for each city.[9]

The main principle in the compact city theory is high-density development close to or within the city core with a mixture of housing, workplaces and shops. This implies densely and concentrated housing development, which favors semi-detached and multifamily housing. Under this theory, development of residential housing areas on (or beyond) the urban fringe, and single-family housing in particular, are banned. Furthermore, central, high-density development supports a number of other attributes that are favorable to sustainable energy use: low energy use for housing and everyday travel, efficient remote heating/cooling systems, proximity to a variety of workplaces and public and private services, as well as a highly developed public transport system.

The supporters of the compact city theory (for example, Jacobs, 1961; Newman and Kenworthy, 1989; CEC, 1990; Elkin et al., 1991; Sherlock, 1991; Enwicht, 1992; McLaren, 1992) believe that the compact city has environmental and energy advantages, as well as social benefits. The list of advantages is remarkably long, including a better environment, affordable public transport, the potential for improving the social mix and a higher quality of life (Frey, 1999). However, the main justification for the compact city is that it results in the least energy-intensive activity pattern, thereby helping us cope with the issues of global warming. The supporters of the dispersed city suggest the green city—i.e. a more open type of urban structure, where buildings, fields and other green areas form a mosaic like pattern (Næss, 1997).[9]

The list of arguments against the compact city theory is even longer than the list in support of it, and includes: that it rejects suburban and semi-rural living, neglects rural communities, affords less green and open space, increases congestion and segregation, reduces environmental quality and lessens the power for making local decisions (Frey, 1999).[9]

However, until fairly recently an international consensus favoring the compact city as a sustainable development approach has dominated the debate (Williams et al., 2000a). Although there has always been considerable skepticism, the concept of the compact city has been so dominant that it seems inconceivable that anyone would oppose the current tide of opinion towards promoting greater sustainable development and the compact city in particular (Smyth, 1996, p. 103). In this context, it is not surprising that the "move towards the compact city is now entrenched in policy throughout Europe" (Jenks et al., 1996, p. 275).[9]

The disagreements between the compact city and dispersed city discourses can to a large extent be summarized as a debate about two issues: which form affords the greater energy efficiency; and, which aspects of sustainable development are more important?

The relationship between urban form and energy efficiency—especially energy use for travel—is at the core of the sustainable urban form debate. During recent decades, there have been a multitude of empirical studies supporting the relative energy efficiency of the two urban forms. Boarnet and Crane (2001) worked through this literature and came to a rather surprising conclusion: "Very little is known regarding how the built environment influences travel" (Boarnet and Crane, 2001, p. 4). Although these authors were referring to the US, we find the same skepticism in Europe. Williams et al. (2000b, p. 355) conclude that "a great deal still needs to be learnt about the complexity of different forms and their impacts". This includes the relationship between urban compactness and travel patterns. A possible relationship between the built form and long leisure-time travel by car and plane is a part of this new knowledge that has to be learnt.[9]

The possible impacts of urban forms are not limited to travel behavior. The built form also influences social conditions, economic issues, environmental quality and ecology within the city (Williams et al., 2000b). All these aspects are also important parts of the sustainable development concept and therefore can be used as criteria for a discussion about sustainable urban form. It should come as no surprise that a study that has minimizing energy consumption as an overall goal, could easily reach different conclusions from those of a study that aims at using urban form to 'reduce the number of people exposed to fine particles' or to 'promote social equity'. In the end, it will be necessary to balance these impacts because sustainable urban form is ultimately about values (Buxton, 2000).[9]

The dispute between the two camps has led to the development of a number of middle positions, which try to combine the best aspects of both the compact and the dispersed city discourses, while at the same time trying to avoid the disadvantages of each. Among such alternative middle positions are the urban village (Newman and

Kenworthy, 1999; Thompson-Fawcett, 2000), 'new urbanism', the sustainable urban matrix (Hasic, 2000), transit-oriented development (Boarnet and Crane, 2001), smart growth (Stoel, 1999) and decentralized concentration (Breheny, 1996; Høyer and Holden, 2003; Holden, 2004). These alternatives all try to combine the energy efficiency gained from a compact urban form with the broader quality-of-life aspects gained from the dispersed city. Still, whether a specific urban form will be more energy efficient is an empirical question.[9]

2. Density

Much of the concern with density in planning and other related fields has been over high urban density and its assumed negative effect on the quality of life of urban residents. The city has historically been perceived to be a place of overcrowding, noise, dirt, crime, poverty, disease, and so forth (Radberg 1998; Lehman and Associates 1995; Gowling and Penny 1988). The high density existing in cities during the early period of the Industrial Revolution was seen as one of the major culprits of poverty and disease. As a result, planning controls (in Canada and Great Britain, for example) usually specified maximum densities. The planning reaction was a strong movement towards lower density housing outside of the city. In the United States and Canada, this took the form of a move to the suburbs, but in Great Britain and Sweden, it resulted in garden cities (Madanipour 1996; Gowling and Penny 1988). The garden city movement is described by Radberg (1998) as representing decentralized urban growth. The assumption was that these relatively low-density residential areas would not suffer from the ills found in high-density cities and would offer a higher quality of life to residents.[10]

More recently, there have been many second thoughts on, and strong criticisms of, these trends. Environmentalists express concern about the environmental implications of low density (Van der Ryn 1986), and urbanists are concerned about the decline of the city (Lehman and Associates 1995; Jacobs 1961) or of the community (Scully 1994; Smyth 1992). Questions about low densities also have been posed by those who are concerned about the efficient use of land and public services (Lehman and Associates 1995); by feminists and researchers who argue that low-density suburbs are inimical to women's lives, especially employed women with children and single parents (Churchman 1993); and by sociologists who criticize the social homogeneity and the social segregation in these low-density areas (Smyth 1992; Shannon and Cromley 1985). There are some, of course, who mention all of these problems (e.g., Calthorpe 1992).[10]

In 1994, a detailed set of principles were set out in Sustainable Development: The UK Strategy (Department of the Environment, 1994a), which was subject to further revision in 1999 (UK Government's Strategy for Sustainable Development, 1999). In this strategy, the landuse planning system was targeted for specific treatment and the foundations laid for more recent policy statements on car usage and urban layouts:[11]

(24.20) Urban growth should be encouraged in the most sustainable settlement form. The density of towns is important. More compact urban development uses less land …

The scope for reducing travel, especially by car, is dependent on the size, density of development and range of services on offer…

(24.26) Town and city centers must incorporate the best principles of urban design …

Indeed, the commission recommended that planning guidance should increasingly reflect the growing sustainable agenda and became much more integrated with other public policy areas, notably economic policy.[11]

Hitchcock (1994) and Orchard (1995) direct attention to the fact that, on the whole, the discussion about increasing density and reducing urban land consumption concentrates almost totally on residential densities. It neglects all of the other land uses that make up a city, even though these land uses represent a significant proportion of a city's total land area. If these nonresidential land uses are not taken into account, the reduction in land consumption achieved by increasing residential density will not be as great as initially conceived because services and amenities will have to be augmented to accommodate the increased population (see also Goodchild 1994).[10]

There are a number of advantages from increasing densities, which can be summarized as follows:[10]

1. It can help protect agricultural land from urbanization (Alterman 1997; Burton and Matson 1996).
2. It results in less depletion of the natural resources needed for construction purposes (Breheny 1992a).
3. Built forms that facilitate higher net densities may result in significant reductions in energy demands (Owens 1992; Stenhouse 1992). Energy use within buildings can be reduced by passive solar architecture, superior insulation, and energy-saving technology (Stenhouse 1992) or by built forms with low-surface areas and combined heat/ cooling and power systems (Rydin 1992). Owens (1992) notes that very different densities (ranging from 37 to 250 dwelling units per hectare) are attainable using combined heat and power systems, depending on discount rates and fuel prices.
4. Decreased pollution from vehicle exhausts can be achieved as a result of a decline in the use of cars, the mixing of land uses, the provision of efficient and accessible public transportation, and walking (Stenhouse 1992; Owens 1992). High densities have been found to be associated with lower gasoline

consumption per capita (Breheny 1996; Newman and Kenworthy 1989); however, this is a controversial issue (e.g., Gordon and Richardson 1997; Jenks et al. 1996a; Orchard 1995).

5. Decreased emission of pollutants may result from energy-saving land use plans and from energy efficient buildings (Breheny 1992a).
6. High density may result in a decrease in the total number of car trips (Breheny 1992a). Nasar (1997) found lower automobile dependency scores in high- versus low-density neighborhoods. These differences were greater for older people, women, and households with no children. Also a decrease in the number of kilometers per trip (Bannister 1992; Stenhouse 1992; Woodhull 1992; Berridge Lewinberg Greenberg, Ltd. 1991b).
7. High density has been found to be related to a higher proportion of travel on public transit, to greater public transit service provision per person, and to transit use by a higher proportion of workers (Breheny 1996; Newman and Kenworthy 1989). Increased public transit use, in turn, may reduce pollution emissions (an environmental advantage).
8. High density enhances the opportunity to use public transportation, since high density brings the development of public transportation systems to the thresholds of profitability and efficiency. The report prepared by Berridge Lewinberg Greenberg, Ltd. (1991b) adopts several benchmarks for the relationship between residential density and transit use. It suggests that 17 to 75 dwelling units per net hectare are necessary to sustain significant transit use, and 150 dwelling units result in a modal split of different transportation types in which more than 50 percent is public transit.
9. As a result of an increase in transit use, traffic congestion in residential, work, and commercial centers may decrease (Berridge Lewinberg Greenberg, Ltd. 1991b).
10. Public transit can be more energy efficient (Reid 1986). Handy (1996) reminds us that it is the set of choices correlated with density, not density itself, that shapes travel behavior. Bannister (1992) discusses the interaction between socioeconomic circumstances and people's propensity to travel with different frequencies, trip lengths, and transportation modes. Gender should be added to these intervening variables (Pickup 1984). Self (1997) questions the effect that a change in density would make. He argues, for example, that a 50 percent increase in the density of Canberra, Australia, would produce only a modest increase in public transit use.
11. It offers more opportunities to walk or ride a bicycle to work, service, and entertainment facilities (Bannister 1992; Woodhull 1992).
12. High densities may result in economies of scale that facilitate the use of better quality and more attractive building materials (Hitchcock 1994).
13. It enables the use of a building complex as an element of the urban composition (Hitchcock 1994).
14. It allows for a variety of densities and types of construction in a given region. Variation in density and construction, in turn, makes the environment more interesting (Hitchcock 1994).
15. High-density development in the proximity of public transportation lines can decrease the demand for land located further from these lines (Shireman 1992).
16. High-density development as infill in existing areas can revitalize those areas and reduce the pressure to develop open spaces (Berridge Lewinberg Greenberg, Ltd. 1991a).

On the other hand, urban density is a major factor that determines the urban ventilation conditions, as well as the urban temperature. Under given circumstances, an urban area with a high density of buildings can experience poor ventilation and strong heat island effect. In warm-humid regions, these features would lead to a high level of thermal stress of the inhabitants and increased use of energy in air-conditioned buildings. However, it is also possible that a high-density urban area, obtained by a mixture of high and low buildings, could have better ventilation conditions than an area with lower density but with buildings of the same height. Closely spaced or high-rise buildings are also affected by the use of natural lighting, natural ventilation and solar energy. If not properly planned, energy for electric lighting and mechanical cooling/ventilation may be increased and application of solar energy systems will be greatly limited.[4]

B. Land Use Distribution and home- work trip

The distribution of uses over the city plan is the main driving or restraining force of transportation. It is those trips made to different facilities that shape our daily activities, whether going to work, or using educational, health, or other public services, or just for leisure. Housing location influences the distances to different types of facilities and the spatial location of most of these facilities suggests that average travel distances will be shortest for inner-city residents. However, there are claims that high accessibility to different services might create an increased demand for transport. Moreover, opting for a wider range of jobs, shops and leisure activities, might establish the need for more everyday travel.

1. New Urbanism and Transit Oriented Development

In urban design literature the development of what is loosely referred to as 'new urbanism' applies a raft of sustainable objectives to new urban layouts. The evolution of this movement may be traced to the development of urban villages (in the UK) and sustainable growth management projects, also known as New Urbanism (in the US), that have been "directed towards creating an alternative to the typical car-dominated suburban sprawl that predominates on the fringe of virtually all western cities and towns" (Morris & Kaufman, 1998, p. 207).[11]

A key design principle in New Urbanism is the creation of a 'module' or 'ped-shed' (walkable urban design and sustainable placemaking), comprising a walkable neighbourhood of 400 m radius to shops, services and transport nodes in which the urban design or fabric creates a series of interconnected streets that are pedestrian friendly, without necessarily banning the private car, and serves to "maximize interaction while minimizing the travel needed to do it" (Morris & Kaufman, 1998, p. 209). The natural corollary of this approach is that car parking provision is dramatically reduced, from the predominant post-war patterns of two or three spaces per dwelling, to one space or less. A link is established between reduced car parking standards and the design of mixed uses, small street blocks and interconnected streets (Walsh, 1997). At a more fundamental level, conventional Western post-war car parking layouts are challenged by the need both to raise residential densities to make for greater land-use efficiencies (Llewelyn-Davies et al., 1994b) and to foster non-car-based trip generation (McMullen, 2000). In this respect a provision of less than one space per dwelling is a desirable objective (McMullen, 2000). Morris & Kaufman acknowledged that this focus on new urbanism will make a significant contribution to achieving more sustainable cities, yet voiced concern that "while the intentions and potential to re-shape cities and towns towards less car dependence is a strong thrust of many practitioners of new urbanism, the evidence of major gains on the ground is limited" (Morris & Kaufman, 1998, p. 208).[11]

The two approaches, new urbanism and transit oriented development do not target increasing densities—any increase in density that is achieved is basically a by-product of a minimal nature. The emphasis of the new urbanism movement is on small towns. New urbanists envision towns or neighborhoods that are compact, mixed use and pedestrian friendly (Madanipour 1996). The emphasis of transit-oriented development, whose principal proponent is Peter Calthorpe (1993, 1992), is to plan balanced, mixed-use areas with a simple cluster of housing, retail space, and offices within a one-quarter mile walking radius of a light rail system. The motivation for transit-oriented development is to improve the ills brought about by dependence on the automobile and the mismatch that exists between old suburban patterns and the postindustrial culture. The goal is to preserve open space and reduce automobile traffic without necessarily increasing density. Calthorpe (1993) defines average net residential densities of urban transit-oriented developments as 44 dwelling units per hectare, with densities of 62 to 123 units per hectare for up to three-story apartment buildings.[10]

2. Long-distance Leisure-time Travel: Compensatory Travel?

An important question that arises from looking at the wider issue of energy use and greenhouse gas emissions is whether, for certain income levels, reduced local everyday travel will be compensated for by increased long-distance leisure travel at other times. Is it the case that—for certain income levels— the sum of 'environmental vices' is constant and that households managing on a small everyday amount of transport, create even heavier environmental strain through, for instance, weekend trips to a cottage or long distance holiday trips by plane? In the professional debate, some (for example, Kennedy, 1995) have claimed that people living in high-density, inner-city areas will, to a larger extent than their counterparts living in low-density areas, travel out of town on weekends—for instance, to a cottage—in order to compensate for the lack of access to a private garden. In addition to this 'hypothesis of compensation', others, including the Swedish mobility researcher Vilhelmson (1990), have launched a 'hypothesis of opportunity' which asserts that the time and money people save due to shorter distance daily travel, will probably be used for long-distance leisure-time travel.[9]

A study conducted in Norway suggested that the total energy use decreases as density reaches a certain point, while the data indicate that the total energy use increases at higher density levels. Figure 5 shows the total energy use per capita for housing and both everyday and leisure-time travel as a function of housing density in the eight residential areas of the study in Norway. This pattern is similar to a pattern in the relationship between energy use and city size found by a number of empirical studies of cities in Norway, Sweden and England (Næss, 1997). According to these studies, up to a certain point, energy use per capita decreases as density increases, but thereafter energy use starts to increase. Thus, the advantages of 'mega-cities' or 'extreme density areas' seem to be outweighed by the advantages offered by more modest forms of urban compactness.[9]

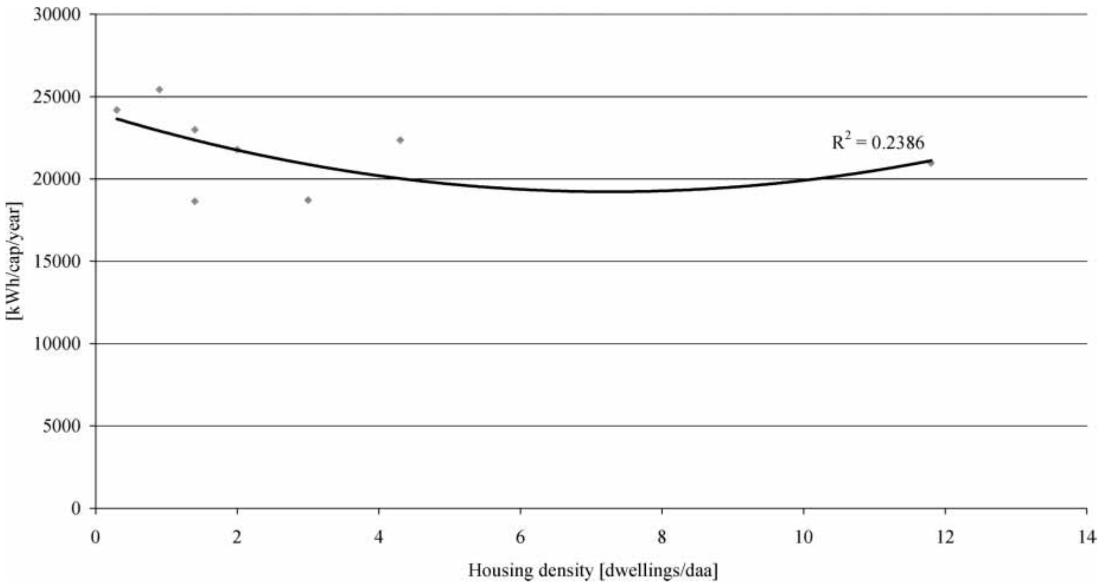

Figure 5 Annual energy use per capita for housing and transport as a function of housing density.[9]

C. Road network and transportation network

Transportation is the leading consumer of energy and fuel in the city. The spread of roads between extended urban areas have helped people commuting easily between these vast areas. Thus, making distances irrelevant and promoting more and more dispersion.

1. Road network

The road network connects the various parts of the city, and the city with its surrounding context. Thus, it attributes to the efficiency of the city, the flow of both people and goods and consequently the economic cycle.

However, the emphasis on road network design has created not so lively neighbourhoods. This was expressed by The Prince's Foundation when examining 'Sustainable Urban Extensions' in the UK, in which the problem is summarized thus:

> House builders place a high priority on complying with rules and guidance on highway engineering. They are anxious that their estates' street system should be adopted by the local authority with the minimum of negotiation and delay. Estates are consequently designed around road layouts based on loops, dead-end spines and cul-de-sacs, whose principal aim is to handle road traffic as efficiently and safely as possible. But as well as discouraging travel on foot or by bicycle, these 'roads first–houses second' designs can damage the harmonious grouping of houses and visual quality… (The Prince's Foundation, 2000, p. 1).[11]

2. Transportation

Since a compact city strategy is recommended to be adopted, an emphasis on the development of rail transport of great accessibility, safety, sustainability, environmental friendliness is the main target. In a study conducted in 25 megacities, the following was found:[1]

- Transportation is seen as the single biggest infrastructure challenge by a large margin, and is a key factor in city competitiveness.
- With air pollution and congestion emerging as the two top environmental challenges, stakeholders predict a strong emphasis on mass transit solutions.
- Cities are more likely to focus on incremental improvements to existing infrastructure, rather than new systems.
- Demand management is rarely mentioned as a major strategy for addressing the cities' transport problems.

3. Parking

Parking policy is commonly viewed as a complementary measure to reduce car use when combined with other initiatives. Sustainability seeks to establish less reliance than previously existed on private car usage, for example by promoting compact urban development in areas well served by good public transport. Urban design policy promotes a departure from the 'roads first, houses later' philosophy (as dictated by many highway standards) to give precedence to the relationship between buildings rather than strict adherence to predetermined road design in new residential environments. A new design approach to car parking has emerged where there is a shift from the previously adopted orthodoxy of minimum standards to maximum ceilings (i.e. no more than one space per dwelling). Such a trend towards reduction of parking standards (and thus provision) is at variance with the projected growth in car ownership worldwide.[11]

Research studies clearly demonstrate that a trade-off exists between relaxing current car parking standards and raising residential density (Llewelyn-Davies *et al*., 1994b; Oldfield King Planning Ltd, 1998). Urban design commentators and practitioners increasingly lobby in favour of a 'car-free urbanism' in which the sustainable residential neighbourhood is floated on the basis of a radical rethink of density and parking policy (Crilly, 1999). The avoidance of inflexible standards will yield improved layouts, so that "Urban Design when released from density and parking standards has a significant role in estimating the hidden capacity of urban brownfield sites and reclaiming the City back from the car" (Crilly, 1999, p. 10).[11]

D. Buildings: Forms, Heights and Facades Treatment

Globally, buildings are responsible for approximately 40% of the total world annual energy consumption. Most of this energy is for the provision of lighting, heating, cooling, and air conditioning.[4]

One way of reducing building energy consumption is to design buildings which are more economical in their use of energy for heating, lighting, cooling, ventilation and hot water supply. Passive measures, particularly natural or hybrid ventilation rather than air-conditioning, can dramatically reduce primary energy consumption. However, exploitation of renewable energy in buildings and agricultural greenhouses can, also, significantly contribute towards reducing dependency on fossil fuels. Therefore, promoting innovative renewable applications and reinforcing the renewable energy market will contribute to preservation of the ecosystem by reducing emissions at local and global levels. This will also contribute to the amelioration of environmental conditions by replacing conventional fuels with renewable energies that produce no air pollution or greenhouse gases. The provision of good indoor environmental quality while achieving energy and cost-efficient operation of the heating, ventilating and air-conditioning (HVAC) plants in buildings represents a multi-variant problem. The comfort of building occupants is dependent on many environmental parameters including air speed, temperature, relative humidity and quality in addition to lighting and noise. The overall objective is to provide a high level of building performance (BP), which can be defined as indoor environmental quality (IEQ), energy efficiency (EE) and cost efficiency (CE).

Indoor environmental quality is the perceived condition of comfort that building occupants experience due to the physical and psychological conditions to which they are exposed by their surroundings. The main physical parameters affecting IEQ are air speed, temperature, relative humidity and quality. Energy efficiency is related to the provision of the desired environmental conditions while consuming the minimal quantity of energy. Cost efficiency is the financial expenditure on energy relative to the level of environmental comfort and productivity that the building occupants attained. The overall cost efficiency can be improved by improving the indoor environmental quality and the energy efficiency of a building.[4]

Urban planning has a considerable impact on the future energy efficiency of buildings and planners lack useful tools to support their decisions. A study was made presenting a new method based on a genetic algorithm which is able to search for optimum urban forms in mid-latitude climates (35-50°). Here, more energy efficient urban forms are defined as those which have high building absorptance in winter and low summer building absorptance. These forms can be designed by choosing among regular tri-dimensional building geometries with fixed floor space index, which can be parameterized by adjusting the following variables: number of floors, building length ratio, grid azimuth, and aspect ratio on both directions. (Figure 6) The results obtained show that adequate urban planning, based on the consideration of the local radiation conditions as a function of latitude, may result in significantly better building thermal performance. In particular, it is concluded that the highest latitudes are more restrictive in terms of optimal solutions: pavilions (cross-sectional square blocks) are best solutions for latitude of 50° and terraces (blocks infinite in length) are preferred for 45°. For lower latitudes, all urban forms are possible. In terms of grid angle with the cardinal direction, it is concluded that the angle should stay between -15° and +15°, except for the latitude of 50° where it can ranges from -45° to +45°. For slabs and terraces urban forms, the spacing between blocks in the north–south direction should be maximized, quantified by a building-height-to-street-width (aspect) ratio which decreases with the increase of latitude, ranging from 0.6 for a latitude of 35°, to 0.4 for a latitude of 45°. For pavilions, the north–south aspect ratio is independent of latitude and should stay close to 0.7. The pavilion is the urban form which allows for a larger number of floors. (Figure 7)[12]

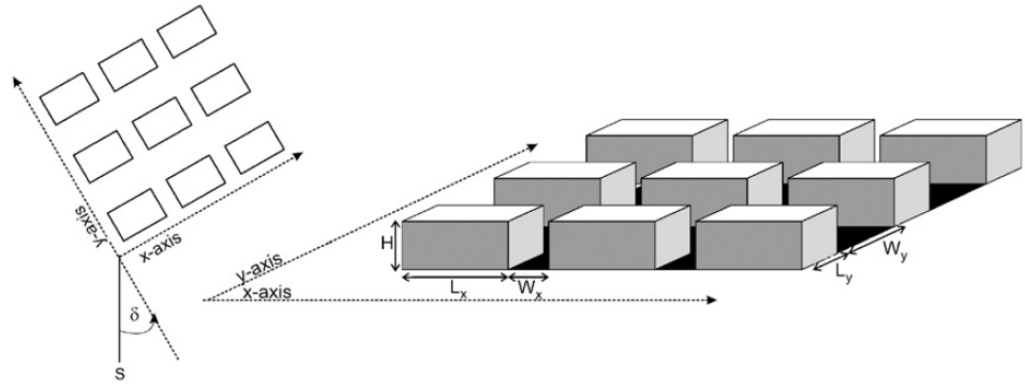

Figure 6 Definition of urban form parameters: grid azimuth (anti-clockwise angle from South, d); building height (H), width (Lx) and depth (Ly); building spacing in x-direction (Wx) and y-direction (Wy).

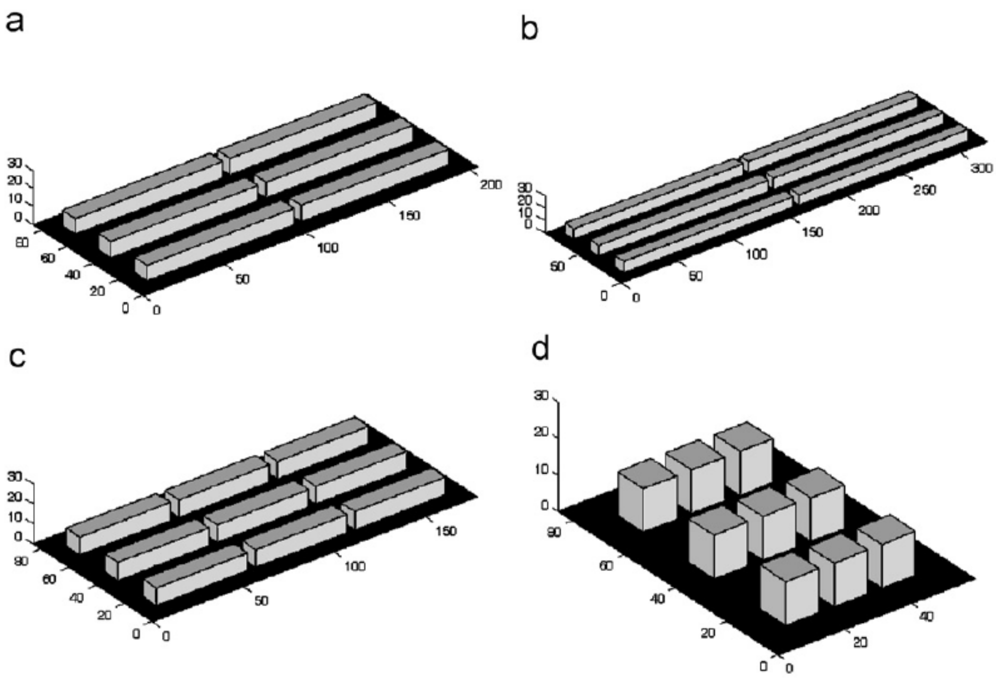

Figure 7 **The varios alternatives of urban forms studied: (a) long slabs, (b) terraces, (c) short slabs, and (d) pavilions.**

Arguably, the most successful designs were in fact the simplest. Paying attention to orientation, plan and form can have far greater impact on energy performance than opting for elaborate solutions. However, a design strategy can fail when those responsible for specifying materials for example, do not implement the passive solar strategy correctly. Similarly, cost-cutting exercises can seriously upset the effectiveness of a design strategy. Therefore, it is imperative that a designer fully informs key personnel, such as the quantity surveyor and client, about their design and be prepared to defend it. Therefore, the designer should have an adequate understanding of how the occupants or processes, such as ventilation, would function within the building. Thinking through such processes in isolation without reference to others can lead to conflicting strategies, which can have a detrimental impact upon performance. Likewise, if the design intent of the building is not communicated to its occupants, there is a risk that they will use it inappropriately, thus, compromising its performance. Hence, the designer should communicate in simple terms the actions expected of the occupant to control the building.[4]

E. Renewable Energy

Research into future alternatives has been and still being conducted aiming to solve the complex problems of this recent time, i.e. rising energy requirements of a rapidly and constantly growing world population and global environmental pollution. Therefore, options for a long-term and environmentally friendly energy supply have to be developed leading to the use of renewable sources (water, sun, wind, biomass, geothermal, hydrogen) and fuel cells. Renewables could shield a nation from the negative effect in the energy supply, price and related environment concerns. Hydrogen for fuel cells and the sun for PV have been considered for many years as a likely and eventual substitute for oil, gas, coal and uranium. They are the most abundant elements in the universe. The use of solar energy or PVs for the everyday electricity needs has distinct advantages: avoids consuming resources and degrading the environment through polluting emissions, oil spills and toxic by-products. A 1-kW PV system producing 150kWh each month prevents 75 kg of fossil fuel from being mined. It avoids 150 kg of CO_2 from entering the atmosphere and keeps 473 lit of water from being consumed. Electricity from fuel cells can be used in the same way as grid power: to run appliances and light bulbs and even to power cars since each gallon of gasoline produced and used in an internal combustion engine releases roughly 12 kg of CO_2, a GHS that contributes to global warming.[4]

The sunlight is not only inexhaustible, but, moreover, it is the only energy source, which is completely non-polluting. The World Summit on Sustainable Development in Johannesburg in 2002 committed itself to ‘‘encourage and promote the development of renewable energy sources to accelerate the shift towards sustainable consumption and production’’. Accordingly, it aimed at breaking the link between resource use and productivity. This can be achieved by the following:

- Trying to ensure economic growth does not cause environmental pollution.
- Improving resource efficiency.
- Examining the whole life-cycle of a product.
- Enabling consumers to receive more information on products and services.
- Examining how taxes, voluntary agreements, subsidies, regulation and information campaigns, can best stimulate innovation and investment to provide cleaner technology.

Figure 8 Using PV modules

To date, renewable energy contributes as much as 20% of the global energy supplies worldwide [DEFRA, Energy Resources. Sustainable development and environment; 2002]. Over two-thirds of this comes from biomass use, mostly in developing countries, some of it unsustainable. Yet, the potential for energy from sustainable technologies is huge. On the technological side, renewables have an obvious role to play. In general, there is no problem in terms of the technical potential of renewables to deliver energy. Moreover, there are very good opportunities for RETs to play an important role in reducing emissions of GHGs into the atmosphere, certainly far more than have been exploited so far. However, there are still some technical issues to address in order to cope with the intermittency of some renewables, particularly wind and solar. Yet, the biggest problem with relying on renewables to deliver the necessary cuts in GHG emissions is more to do with politics and policy issues than with technical ones (DEFRA, 2002). For example, the single most important step governments could take to promote and increase the use of renewables is to improve access for renewables to the energy market. This access to the market needs to be under favorable conditions and, possibly, under favorable economic rates as well. One move that could help, or at least justify, better market access would be to acknowledge that there are environmental costs associated with other energy supply options and that these costs are not currently internalized within the market price of electricity or fuels.[4]

Renewables are generally weather dependent and as such their likely output can be predicted but not controlled. The only control possible is to reduce the output below that available from the resource at any given time. Therefore, to safeguard system stability and security, renewables must be used in conjunction with other, controllable, generation and with large-scale energy storage. There is a substantial cost associated with this provision.

It is useful to codify all aspects of sustainability, thus ensuring that all factors are taken into account for each and every development proposal. Therefore, with the intention of promoting debate, the following considerations are proposed:[4]

(1) Long-term availability of the energy source or fuel.
(2) Price stability of energy source or fuel.
(3) Acceptability or otherwise of by-products of the generation process.
(4) Grid services, particularly controllability of real and reactive power output.
(5) Technological stability, likelihood of rapid technical obsolescence.
(6) Knowledge base of applying the technology.
(7) Life of the installation—a dam may last more than 100 years, but a gas turbine probably will not.
(8) Maintenance requirement of the plant.

However, the improved energy performance of cities from these kinds of initiatives is usually being outweighed by the increases in the use of fossil fuels by private transports that have occurred in recent years. This is the case all over the developed world, and particularly in the USA and Australia, where low-density urban sprawl has made it very difficult to introduce energy efficient public transport systems. In cities with low density sprawl where most people rely on private cars it will be particularly important to introduce new transport propulsion such as fuel cell technology to make both private transport and public transport both less polluting and more energy efficient.[3]

Really significant breakthroughs in urban energy efficiency and introduction of sustainable energy systems in cities will emerge only as a result of major changes in national energy policy. In some countries we have seen some significant breakthroughs, but far more needs to be done to transform our cities from fossil fuel junkies to sustainable, future-proof systems.[3]

Thus in order to reach a sustainable environment, a combination of policies and actions is essential. (Figure 9) These policies include: sustainable energy production policies, renewable energy production as parts for city planning for energy efficiency. Then combined with users' trends consumption patterns, a sustainable environment can be reached.

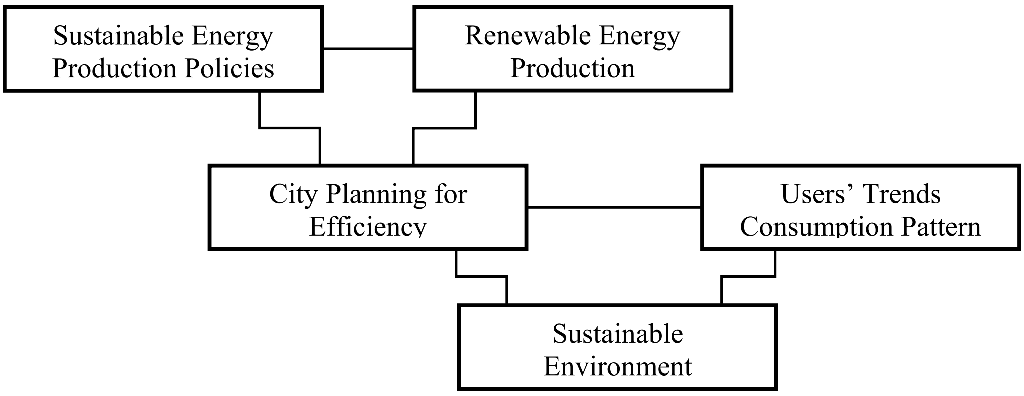

Figure 9The relatioship between policies to achieve a sustainable environment

It is important to note that the know–how exists to bring urban energy use down by 50 % or more without significantly affecting living standards, while creating many new local jobs at the same time. There are some initiatives to improve the energy efficiency of cities, for example, The Cities for Climate Protection Program of The International Council for Local Environmental Initiatives (ICLEI). This is a performance- oriented campaign, started in 1993, offering a framework for local authorities to reduce global warming and waste gas emissions all over the world. This framework includes 5 performance milestones (which are implemented by 500 local governments participating in the campaign in 2004):[13]

- Conduct an energy and emissions inventory and forecast.
- Establish an emission target
- Develop and obtain approval for the Local Action Plan
- Implement policies and measures
- Monitor and verify results.

IV. City Consumption and City Impact

A. Ecological Footprint

In order to measure a city's impact versus its consumption, a more sophisticated analysis has been developed by Rees into a methodology that can calculate a city's Ecological Footprint. (Rees, W (1992), "Ecological Footprints and appropriated carrying capacity", *Environment & Urbanization* Vol 4, No 2, October, pages 121–130; also Wackernagel, M and W Rees (1996), *Our Ecological Footprint: Reducing Human Impact on Earth*, New Society Publishers, Vancouver) This is based on an ecological understanding of how a city extracts food, water, energy and land from a bioregion (and beyond) and requires ecosystem services to absorb its wastes. The total resource use of a city is figured relative to its population, and the resulting calculation allows a per capita footprint of land to be compared to that of other cities.[14]

The EF translates consumption of various types into the common metric: total area of productive land and water ecosystems required to produce the resources that the population consumes and assimilate the wastes that the population produces, wherever on Earth that land and water may be located. (Rees, 2000, p. 371) In calculating the footprint of nations or regions, the different bio-productivities of various land types are taken into account; this is achieved by incorporating equivalency factors, such that the calculated EF is expressed as standardized acres of world-average productivity. EFs quantify humans' overall impact on nature in relation to carrying capacity (Chambers et al., 2000). The average global footprint is 5.4 acres per capita and there are only 4.7 acres available per person based on the biologically productive area divided by the current world population. Hence, we are in a deficit of 0.7 acres per person (Chambers et al., 2000), depleting the earth's natural capital rather than living off nature's interest (Wackernagel & Rees, 1996; Wackernagel & Yount, 1998; Chambers et al., 2000).[15]

The concept of an EF is now firmly ensconced in the environmental literature and, despite its limitations[†] , there is considerable support among researchers and environmentalists for the footprint as a clear, unambiguous indicator of human impact on nature that is easily applied (Herendeen, 2000; Moffatt, 2000; Rees, 2000; Templet, 2000).[15]

One of the important linkages, that is not often drawn, is between Ecological Footprint, urban density and transport energy. Some commentators have criticized the use of per capita car use and per capita land use as confounding the statistics because population is in both denominators.[‡] However, if the population factor is removed, then it is possible to look at whether land area (the direct footprint of a city) relates to transport (Figure 10).[14]

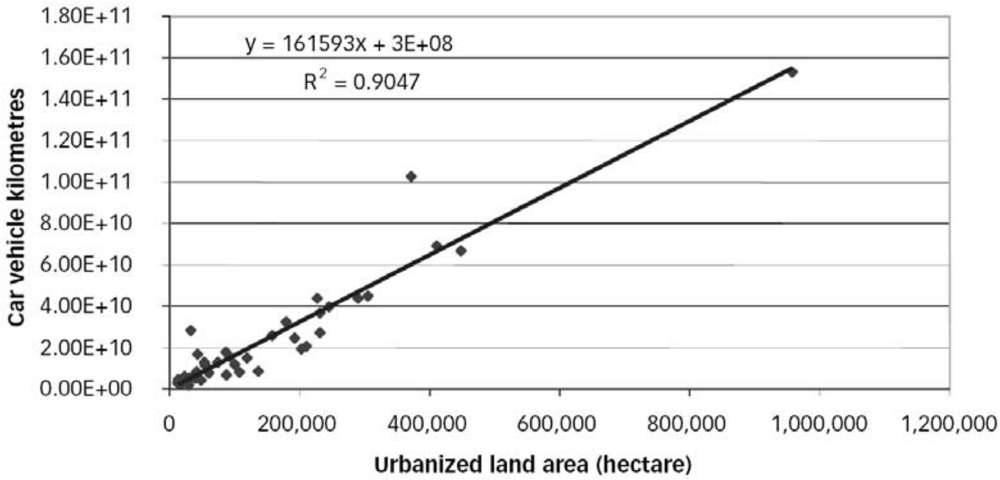

Figure 10 Urbanized land area versus car vehicle kilometres per capita in a sample of world cities, 1990 (Kenworthy, J and F Laube (2001) as cited in Ref. 14)

[†] see, for example, Gordon & Richardson, 1998; Holmberg et al., 1999; Van den Bergh & Verbruggen, 1999; Deutsch et al., 2000; Herendeen, 2000; Moffatt, 2000; Rapport, 2000.

[‡] See Brindle, R E (1994), "Lies, damned lies and 'automobile dependence' – some hyperbolic reflections", *Australian Transport Research Forum 94*, Melbourne, pages 117–131, with a response from Evill,B (1995),"Population, urban density, and fuel use: eliminating spurious correlation", *Urban Policy and Research* Vol. 13, No 1, pages 29–36

One inherent weakness of using the EF is that it, like other inventory tools, is intended to measure impact. EF is not designed to get at cause and effect. However, where qualitative data provide insight into decision-making processes and choices, the EF becomes a useful tool for understanding the pathways to different outcomes. Also, the raw data assembled for its calculation could be used for specific questions of importance in planning practice.
In addition, the EF could be used by policy makers as part of the approvals process for proposed developments. Rather than restricting development according to standard urban design codes, developments could be classified by a maximum EF. It would be up to developers and designers to plan communities that fall within the assigned EF. Rather than crippling innovation and creativity in urban design through legislation, a maximum assigned EF would foster new ideas and designs to tackle the sustainability challenge.[15]

A study on the ecological footprint in EcoVillage at Ithaca, USA, it was found that consumption, not built form, contributes most to the overall footprint; therefore, the link between design and behavior is of critical importance. The experiences at EcoVillage at Ithaca suggest that physical design may be a catalyst or facilitator of some changes in consumption, especially as they relate to utilities and possibly also to transportation, but no overall conclusion on the interaction between design and behavior can be drawn from this study.[15]

B. Sustainability Assessment

Ecological footprint helps when assessing development on the global scale, but on the local scale there is a need for a much comprehensive tool. A key aspect to sustainability assessment is the assistance it provides to complex, controversial urban policy issues. One example is the density of cities and planned developments – a policy area of great controversy in some urban areas. There is a strong global economic rationale for redeveloping car-dependent cities into focused centers and corridors, to make better use of infrastructure at the scale required to provide such local services as public transport, shops and community services within walking distance. The lesser need for transport, the reduced urban sprawl and Ecological Footprint, the far greater opportunities for housing diversity and other equity issues all provide additional justification at both local and global levels. However, those local residents in the area where redevelopment is planned often perceive it as a threat to their local environment and social amenity. Sustainability assessment of such development can ensure there are real global economic, environmental and social benefits (often regional benefits but they may as well be global for many local people), but it can also ensure that developers include real local economic, social and environmental benefits. It can be used to ensure that there is a clear rationale for any development in terms of local environmental benefit (enhancing the local sense of place) and local socioeconomic benefit (clear provision of better services). With these in place, the local and global issues can be seen to be resolved and a net benefit provided.[14]

'Good' planning begins with an assessment of users' needs (Leung, 2003). For example, transit stops are located in a way that is sensitive to demand. However, planning may also help to shape demand. Indeed, the very existence of planning reveals some general level of acceptance that land markets require guidance, and there is a growing sense that planners ought to have a right to ask people to change behavior if they can prove that a present behavioural pattern or community arrangement is dangerous to the people concerned or to others (Gans, 1969). Environmental externalities may be the single most compelling argument against sprawl (Krieger, 2004). Suburban development has devoured many wetlands, for instance, with consequences for future water quality and supply (Draper, 1998; Pollard, 2001). Auto-dependence and associated air pollution have severe implications for those with respiratory problems, and carbon dioxide emissions may contribute to climate change with unforeseeable consequences.[15]

Cities will always be centers of consumerism. However, we can change the way they utilize resources. This can be done by conceptualizing cities as sustainable eco-technical systems, which requires converting their largely linear resource throughput into circular resource flows. Energy efficiency, resource productivity, urban and industrial ecology are key terms in this context.[12]

V. Roles of stakeholders in planning for energy efficiency

A. Legislations and laws addressing environmental issues

In order to achieve more energy efficient cities, where development is sought to be sustainable and environmentally responsive, laws and legislations should play a vital role. In 2000, the city of Barcelona introduced its mandatory 'Solar Ordinance'. All new housing, offices, restaurants and public buildings there have to install solar hot water systems if they use substantial amounts of hot water. Old buildings also have to be fitted with solar hot water systems when they are refurbished. Around the Mediterranean use of solar hot water systems has become commonplace. In Japan about 10 per cent of all dwellings have their own solar hot water systems.[3]

In German cities solar PV panels are becoming commonplace, despite the country's relatively cloudy skies. This is primarily due to the German government's 'feed-in' legislation which has fixed both subsidies and favorable tariffs for owners of PV roofs. They are paid about 50 cents/kWh for selling their electricity back to the electricity grid, which is about four times the price paid to conventional electricity generators. The policy has led to a massive growth in demand for solar PV technology across the country. Similar policies have now been introduced in Austria, France and Spain.[3]

B. Governance

Better governance is a vital step towards better cities. With so many areas crying out for investment in better infrastructure, it is not surprising that funding emerges as a big issue for many stakeholders in the survey. But for those involved in city management, it is improvements to governance — rather than just money — that are the top priority going forward. Over half of respondents with knowledge of urban management see improved planning as the priority to solving city problems, compared with only 12% that prioritize increased funding. In addition to more strategic planning, there is also a strong focus on managing infrastructure and services more efficiently. Both these goals will require cities to make the step from passive administration of existing services, to a more active style of managing systems that focuses on improved efficiency and more measurable outcomes.[1]

There is also a relationship between the scale of the environmental burdens and the appropriate roles of different levels of government. Some governance failures can be traced to a mismatch between the scale of the problem and the scale at which the response has been articulated. Local governance should not be expected to reduce carbon emissions voluntarily, although it can be a very appropriate level for driving local water and sanitation improvements. Global governance, on the other hand, is clearly needed to help develop institutional mechanisms to reduce contributions to global climate change, but is inappropriate to developing institutional mechanisms for managing local water and sanitation systems. On the other hand, reducing local environmental burdens often requires support (or at least the absence of opposition) from global processes and institutions, while responses to global burdens often need to be rooted in local agency (Wilbanks and Kates 1999), (McGranahan, 2005). Moreover, cities and their needs are complex and the traditional, departmentally organized approach to city governance needs to be rethought to enable more holistic solutions on the one hand, and more responsiveness and accountability to citizens at a local level on the other.[1]

The search for improved efficiency may require megacities to contract out the management of more services to the private-sector. One of the more surprising findings in the survey is the fact that the main perceived advantage of private-sector operation is improved efficiency, more than access to funding. Where cities do increase private sector involvement, they will need to create the right framework for success. There is a variety of models available, where ownership and operation of services can be shared. But when entering into partnerships with the private sector, the consequences must be well thought through, and success will require a "context-sensitive" approach to privatization, with overall control (and responsibility) resting with the public sector. If comprehensive governance models and efficient management structures are put in place, economic attractiveness, environmental protection and quality of life for all citizens need not be contradictory goals.[1]

Today, there is almost universal recognition in governments at all levels that it is essential to incorporate environmental considerations into urban planning and management. This provides significant benefits in every area of urban life, cutting across issues such as health, poverty, security and economic development. Moreover, there is an essential call for better communication both within the government and with other stakeholders involved in city planning and operation.

VI. The Middle East Context

A. The Gulf Area

1. A Return to Compact Cities

Over centuries, the climate in Arabia has become a major factor that shaped day life of the local societies and thus, the form of their cities. Old cities were characterized by their compactness which stemmed from the need for protection from the harsh environment. Urban fabric has been dominated by the building masses, the limited number of enclosed public and outdoor spaces, and the inward-looking architecture. Besides its environmental utility, compactness also provided a physical support to the local community and reflected its strong social structure and complex network of kinships. Nowadays, Gulf cities that are mostly shaped by the modern movement and American life style are in complete negation with their past. An unprecedented sprawl effect is taking place all over the Gulf countries due to the heavy reliance on private transportation, high building technology, powerful air-conditioning systems and private housing.[16]

A study by Ben-Hamouche on cities in Arabia recognized two historical shifts in the form of the city. The first one occurred during the industrialization era from the old compact city, to the modern dispersed city, and the second shift is expected to occur in the information age from the modern dispersed city back to the post-modern compact city through the combination of the concepts of sustainability and IT. He refers to the New Urbanism movement and its principles in his call for referral to compact cities as a remedy to the cancerous sprawl and suburbia.[15]

Although this study claims that the information age will make the city more compact, due to the diminishing need for mechanical mobility, this increased accessibility might not lead to compactness. The sprawling may continue, only car usage might decrease but not necessarily increasing density.

2. Masdar City: Innovative Technologies[17]

As the geographical core of the Masdar sustainable energy initiative, Masdar City has been one of the elements to move forward the most quickly. The concept is simple but radical; zero-carbon and zero-waste. This involves a radical rethink of everything about the way that the city will function.

Figure 11 Masdar city construction

The seven square kilometre site chosen is near the airport and about 17 km from the city of Abu Dhabi, and, were it not in the desert, it would be classified as a 'greenfield' site. The fundamentals of the plan have been agreed, ground broken and phase one is underway. Over $300 million of procurement is in place, and an additional $1 billion is expected to be committed by the end of 2009. The city is due to be built in seven years, at a total cost of $22 billion. The first $4 billion of this is coming from the Masdar Initiative, with the remaining $18 billion being raised through direct investments and other financial instruments.

Figure 12 Masdar's 10 MW solar plant, set to power construction of Masdar City

Sir Norman Foster, the British Architect, is behind the design of the city, and detailed planning and preparation has been done by a range of international consultants and experts, including Pooran Desai from BioRegional, the UK consultancy WSP and US-based CH2M Hill.

a. Building design:

Much of the design will adopt local, vernacular architectural principles, but this will also be mixed with a lot of cutting-edge technology, some of it still in the experimental phase. The city will incorporate traditional medinas, souks and wind towers, and make use both of open, public squares and narrow shaded walkways to connect homes, schools, restaurants and shops. The buildings themselves will then adopt a wide range of passive measures, and should consume well under a quarter of the energy used by comparable buildings elsewhere in the region.

b. Transportation

There will be no cars in Masdar City; indeed, no internal combustion engines of any type. Instead, there will be a network of electric trams (an LRT or light rail transit system, which will also link to the planned Abu Dhabi LRT system), and smaller, 'personal rapid transit' vehicles, effectively an automatic, driverless system of electric taxis controlled by a central computer. These will be programmed so that, once occupied, the passenger has privacy and no other passenger can board along the route.

Figure 13 Masdar City 'waffle-grid' system

c. Renewable Energy:

All the energy used in Masdar will be renewably generated, not only the electrical power, but also that for heating, cooling and transport. The bulk of this is likely to come from solar of one form or another. There will be power generation for a smart grid from solar thermal power and concentrating PV, and also distributed PV throughout the city. The wind resource in Abu Dhabi is generally poor and will contribute little to the overall mix, but some geothermal and waste-to-energy, particularly from bio waste, are also likely to be significant contributors.

As well as providing a regional location, there are also numerous partnership opportunities for companies with technologies that may be used at Masdar. Among the energy technologies they expect to source are both PV and solar thermal power generation (concentrating PV, parabolic trough and parabolic dish generation); advanced thermal waste treatment plants; geothermal systems that can be used for district cooling; and smart grid management systems. They are also looking at a range of other district cooling systems, together with water desalination and grey-water treatment plants, and waste handling systems, including plasma and pyrolysis. More widely, procurement is also underway for IT systems, the transport infrastructure, and facilities management and services.

The Arabic word 'Masdar' was chosen as the name of the project, as one definition of the word is 'source' – in the sense of the root or spring from which things originate. For years, many good renewable energy projects have suffered through lack of access to sources of funding. The Masdar initiative is showing that the combination of good projects and a plentiful source of funding can result in very rapid development of even the most ambitious plans. As such, it may also be a beacon for other places that are contemplating whether large-scale investment in renewables really can pay off.

B. Egypt

There is a growing awareness in Egypt about the change in climate since 1982 when it established the Egyptian Environmental Affairs Agency (EEAA). Egypt was also one of the first Arab countries to sign the United Nation Framework Convention on Climate Change (UNFCCC) in 1992. Egypt has participated in and made several actions in dealing with climate change and environmental issues, for example:[18]

- Ratification on the United Nations Framework Convention on Climate Change, the issuance of Law 4/1994 for the Protection of the Environment, and the participation in various international workshops and conferences related to climate change to avoid having any international obligations on developing countries, including Egypt.
- Ministry of Electricity and Energy established several projects in the field of New and Renewable Energy (Wind - Solar - Hydro - Bio), and encouraging Energy Efficiency Projects.
- Ministry of State for Environmental Affairs established guiding schemes for private sector to encourage investments in the field of clean energy projects, waste recycling, and afforestation.
- Re-structuring of the National Committee of Climate Change in 2007, as coordinator on the national level related to climate change issues, putting a visionary for needed policies and strategies to deal with it, and suggesting mechanisms required for implementation
- Maximizing the benefit from Kyoto Protocol Mechanisms through implementing Clean Development Mechanism Projects.

An energy code for building performance has been prepared by the Housing and Building Research Center (HBRC). It specifies the energy consumption of buildings according to their use and typology. This was an initiative to make buildings more energy efficient, however this code has not been yet implemented.

1. Strategic Planning For Cities Program

On the urban planning level there has been a lot of efforts since 2008 to upgrade the Egyptian cities (around 200 cities). The program conducted by the General Organization of Physical Planning GOPP started in 2008 for strategic planning of cities under the auspicious of the Ministry of Housing. A parallel program is run and funded by the UN-HABITAT concerning small cities; i.e. 25000 – 50000 inhabitants.

It is important to note that continuous urbanization of rural areas in Egypt has created a unique case. One can find cities that are just villages in their structure, plan, network and both physical and social infrastructure. These cities comprise most of the Egyptian urban context. This is primarily due to the way a city is defined by the government (according to population size). Typically, a city is defined as a settlement with more than 25000 inhabitants. In other words, a village could become a city when its population exceeds this limit, however it will still hold its rural characteristics, way of life, function and physical features.

In the context of the strategic planning of cities, 3 main sectors are studied: shelter and informal areas, infrastructure and local economic development. Three other sub cross cutting sectors are investigated: local governance, environment, and poverty, women, and vulnerability. Its main activities include preparing city profile for the sectors investigated; a list of projects that are required by the city and represent its priorities, a strategic plan with these projects situated in the appropriate locations and showing the road network, land uses and city limits. All processes are conducted with a participatory approach, where all the city stakeholders are involved in the process of planning, prioritizing and decision making. The final product is the strategic plan for the city.

The environment sector is mainly concerned with environmental hazards, pollution, noise, solid waste management and recycling. There is no mentioning of energy responsiveness or planning for maximizing efficiency of energy use. However, these issues might be tackled depending on the environment consultant concept and the local context of the city under study.

Despite the program negligence of the energy responsive strategies, it provides a unique opportunity to really make our cities green and energy responsive. There are a number of ideas and actions that if gathered and formulated into a strategy could present a pioneer example in local contexts of the developing world.

In the progress of strategically planning Ashmun city in the governorate of Menoufia, Egypt, a number of ideas and requests were submitted by the local community that are energy responsive in the essence, for example: (Figure 14)[19]

- Preserving city boundaries with minimal increase just to accommodate future needed services and the preservation of agricultural land.
- The need to build a ring road to increase transportation efficiency and decrease energy consumption and pollution.
- Increasing the heights to double the street width (law specifies max building height = 1.5 street width) in structurally fit buildings to become 4 floors instead of only 3 floors. Thus densifying existing urban areas instead of horizontal spread of the city.
- Non inclusion of sprawling houses in city limits in order to prevent or minimize future expansion on agricultural land.
- Wise location of needed services, appropriate rates per capita of services and facilities, and their concentration in single location central to community.
- Advocating mixed uses as commercial/ residential uses.
- Locating workshops in a special area outside the residential mass, increasing efficiency of operation, management and transportation to other cities for further manufacturing.
- The need to replace old deteriorated water supply asbestos pipes to prevent leakages and minimize health problems.
- Better road network linkage with surrounding settlements for better and efficient transportation. Proposing a bridge to decrease travelling distance to neighbouring industrial zone (Sadat city). Thus providing jobs, preventing agricultural land loss, and advocating more efficient industrial centres.

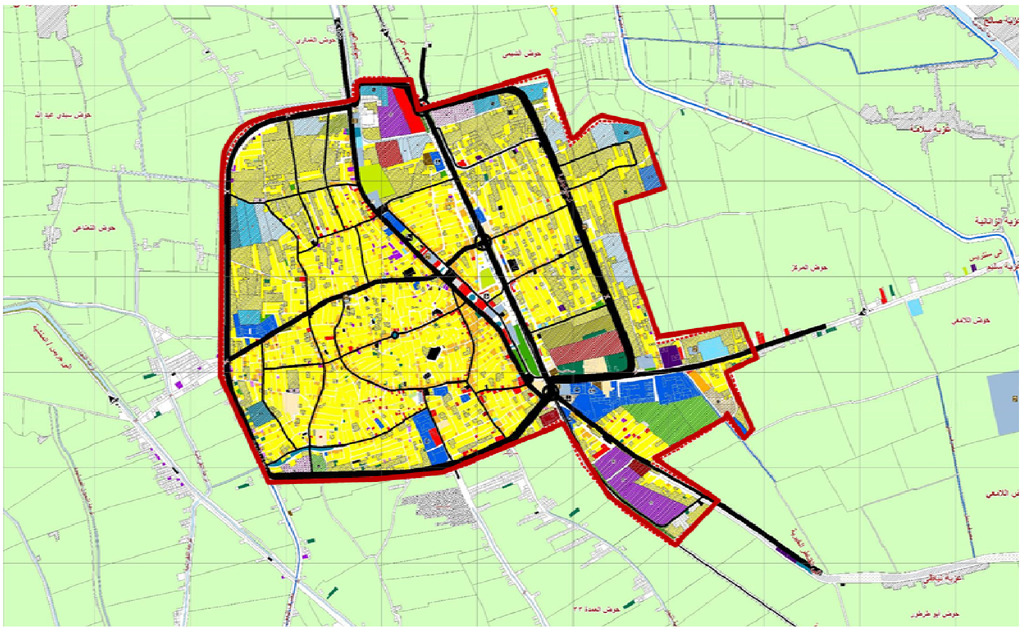

Figure 14 Keeping Ashmun city boundaries to the minimum and preserving surrounding agricultural land.[19]

These ideas were required and enforced by the local community and the elected leaders which shows awareness to the pressing issues of energy responsiveness and the conventional resources depletion, despite a direct correlation to energy efficiency was not explicit. But this subtle concern can provide a solid base for more action to provide strategies for planning for energy efficiency in Egyptian cities.

2. *Cairo*

Cairo is rated to be second worldwide for its pollution rate. (Figure 15) It is rated as a mega city with around 18 million people living in Greater Cairo region and consists of 5 governorates. This expansion has caused many problems concerning environment, quality of life, and infrastructure. Basically Cairo is denser than many other cities, as the law specifies allowed maximum density of 150 person/ feddan (357 persons/ hectare), so it does not need to get denser. However, there is a need to revise the current development strategies concerning the sprawling communities around the city. These gated communities are a replica of the American image of the perfect housing environment, where a villa exists on a private piece of land with front lawn and a back garden. The building density is as low as 25% (down town can reach 60 and 70%) to accommodate for the extended open spaces. These communities were originally a part of the green belt that was designated to surround Greater Cairo. However, there was a shift towards transforming it into dwelling areas, but with low densities, as an attempt to preserve the concept of the green belt.

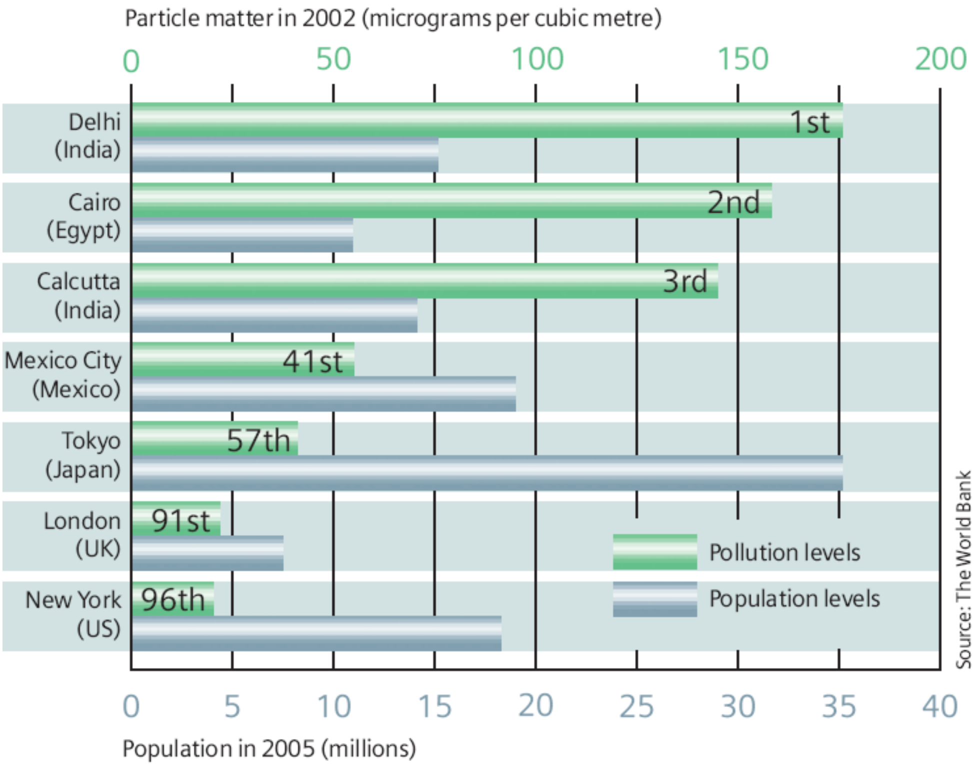

Figure 15 World's most polluted cities, source: The World Bank as cited in Ref. 1

Although there is a growing demand for these communities, they are far from being environmentally friendly. The extension towards new cities of Sheikh Zaied and 6th of October on one side and city of Obour, Elshorouk and New Cairo on the other side of Cairo defies the original concept of establishing these cities as separate cities and transforms them to parts or districts of the ever growing Greater Cairo. (Figure 16)

This has really affected energy consumption trends especially for increasing car dependency. The lack of an adequate transportation system that links all spread out areas increases car dependency and fuel consumption. The home work trip is becoming a daily nightmare, in the middle of a congested traffic with a continuous peak hour.

Moreover these gated communities and nearby new cities lack sub centres providing adequate services or businesses. Thus a trip to down town Cairo is essential to obtain services.

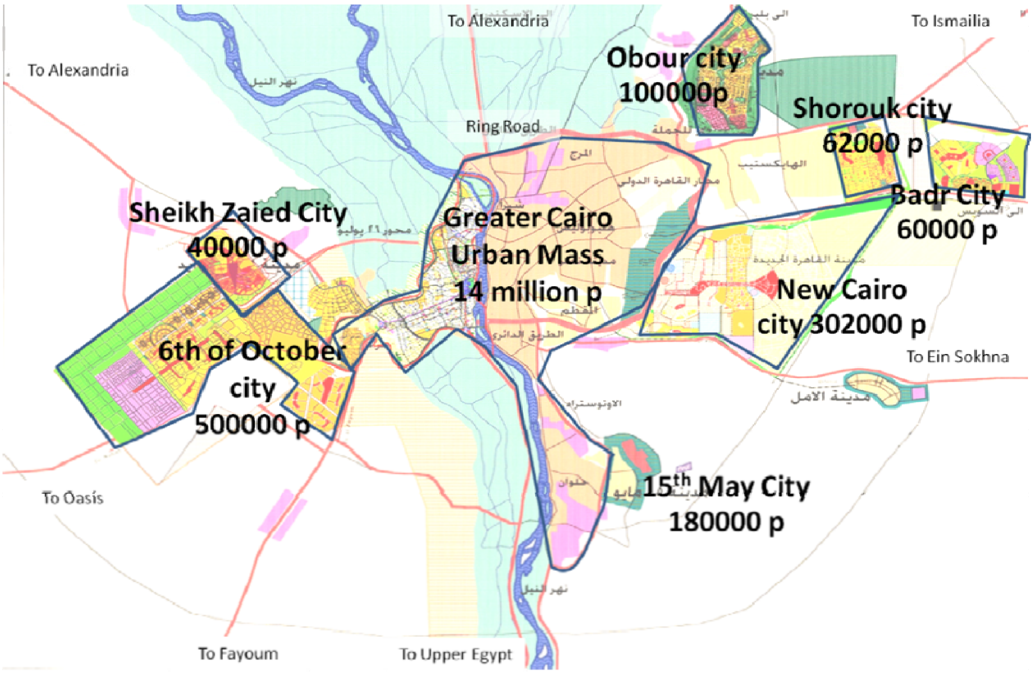

Figure 16 Greater Cairo with the surrounding new cities

VII. Conclusion

In November 2007, UN-HABITAT held an Expert Group Meeting on “Cities in Climate Change” in Nairobi, Kenya, bringing together participants from UN agencies, research institutions, local authorities, and the private sector. The experts discussed the role of UN-HABITAT regarding climate change and worked out basic elements for the agency’s strategy on cities in climate change. The main outcomes of the Expert Group Meeting are that UN-HABITAT has a clear role to play in dealing with climate change at the local level with a special focus on urban areas in developing countries. Furthermore, climate change should be regarded as a cross-cutting issue and integrated into UN-HABITAT’s existing initiatives and programmes.[20]

The experts underlined the importance of immediate action, e.g.:

- Launching of the Sustainable Urban Development Network (SUDNet) in 2008 for strengthening the performance of local governments to enhance climate change mitigation and adaptation measures in developing countries through existing and new partnerships;
- Promoting city-to-city cooperation;
- Conducting vulnerability assessments and risk mapping at the local level and providing guidelines for adaptive local planning;
- Collecting and sharing case studies on good practice;
- Developing mechanisms to assist cities in preventing land-use conflicts arising from relocation of human settlements; and
- Assisting governments in translating National Adaptation Plans of Action to Local Adaptation Plans of Action together with adequate transfer of resources.

This is in line with the experience gained from the Strategic planning for cities program in Egypt, as the actions required by the experts are what the program in Egypt lacks on the broad level.

What can be done in the developing countries is a lot. In the Egyptian context there is a need for more awareness and action towards energy efficient strategies and integrating them in urban planning. These strategies can be summarized as shown in Figure 17. On the personal level it is recommended to try to use one’s car less and separate his garbage as the former mayor of Curitiba, Brazil advises.[13]

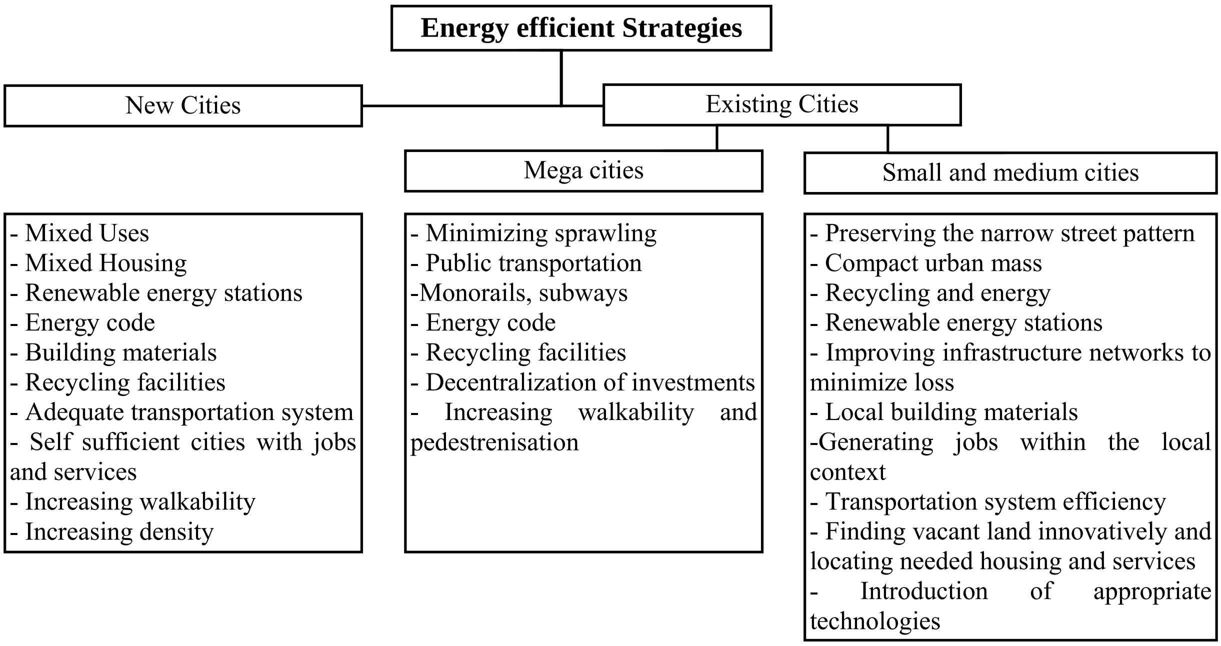

Figure 17 Energy efficiency strategies in cities

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