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Readiness for EcoCities in Egypt

Insights into the current state of EcoCity systems, technologies and concepts

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Abstract

The objective of this report is to provide a general overview of the current state of urban planning, energy systems, water and waste management, transportation planning and raising general awareness. One objective is also to provide some general information about what the EcoCity concept means in the Egyptian context. Some case examples are given in order to give an idea of the practical conditions on the ground.

An EcoCity essentially has high ecological quality, but at the same time it is technologically sophisticated and modern. The attempts to build an EcoCity so far have been based on optimization of different sectors or technologies, and thus they are a compromise between the high-level targets and the present level of design. However, there is not just one EcoCity concept but a variety of possibilities that need to be adjusted to fit the local context, local culture and local economic realities. This is the way to achieve a possible solution with regard to the local resources, but at the same time to meet the high goals set for an EcoCity. High-tech solutions are one way to the EcoCity, but they are not the only goal of an EcoCity.

The main elements of an EcoCity are a dense city structure, clean energy production, minimal energy consumption, sustainable transport solutions, ecological water and waste solutions and the inclusion of social aspects.

In Egypt the biggest challenges in terms of EcoCities concern transportation. Bigger cities have big problems with too many private cars and the lack of functioning public transportation systems.

Water resources are scarce in Egypt, and they have therefore to be given special focus when planning sustainable city structures. There is a high level of know-how about water handling systems. The main challenges are in finding investments for the solutions.

As regards energy, there is a major saving potential in terms of electricity usage. Regarding renewable sources, the biggest potential is in solar energy.

To achieve sustainable cities, focus must also be put on awareness-raising activities and on developing governance structure.

Keywords EcoCity, city planning, renewable energy, sustainability

Preface

The aim of this publication is to give an insight into the current state of Egypt's EcoCities and aspects related to those. These aspects cover urban planning, energy systems, water and waste management, transportation planning and general awareness-raising. The publication has been written in co-operation between the Egypt-Japanese University of Science & Technology, E-JUST and VTT Technical Research Centre of Finland. Experts from Alexandria University and Cairo University have also contributed to this report. This publication is part of the joint project "EcoCity Capacity building in NBC" which aims to raising the capacity of the EcoCity know-how within E-JUST. The project is funded by the Ministry for Foreign Affairs of Finland.

Contents

List of symbols

(Bbl)	Barrel
(Bcm)	Billion cubic metres
(BOOT)	Build-own-operate-transfer
(CDM)	Clean development mechanism
(CFC)	Chlorofluorocarbon
(CH4)	Methane
(CO)	Carbon monoxide
(CO_2)	Carbon dioxide
(EEHC)	Egyptian Electric Holding Company
(EETC)	Egyptian Electricity Transmission Company
(EEUCPRA)	Egyptian Electric Utility and Consumer Protection Regulatory
(GEF)	Global environment facility
(GHG)	Greenhouse gas
(H_2SO_4)	Sulphuric acid
(IRENA)	International Renewable Energy Agency
(ITS)	Intelligent transport systems
(LE)	Egyptian Pound
(LNG)	Liquefied natural gas
(MENA)	Middle East and North Africa
(MWh)	Mega Watt hours
(N_2O)	Nitrous oxide
(NBC)	New Borg El Arab City
(NGO)	Non-governmental organizations

(NO)	Nitrogen oxides
(NOx)	Nitrogen oxide
(O_3)	Tropospheric ozone
(Pb)	Lead
(PCF)	Prototype carbon fund
(PPA)	Power Purchase Agreements
(PV)	Photovoltaic
(RE)	Renewable Energy
(SO_2)	Sulphur dioxide
(SWM)	Natural gas liquids
(SWM)	Solid waste management
(Tcf)	Trillion (10^{12}) cubic feet
(USAID)	U.S. Agency for International Development
(USD)	United States Dollar
(WED)	World environmental day
(WHO)	World Health Organization
(VOC)	Volatile organic compounds

1. Introduction

The aim of this publication is to give an insight into the current state of Egypt's EcoCities and aspects related to these. These aspects cover urban planning, energy systems, water and waste management, transportation planning and a general awareness-raising. This publication has been written in co-operation between the Egypt-Japanese University of Science & Technology, E-JUST and VTT Technical Research Centre of Finland. Experts from Alexandria University and Cairo University have also contributed to this report. The publication is part of the joint project "EcoCity Capacity building in NBC" which aims to raising the capacity of the EcoCity knowhow within E-JUST. The project is funded by the Ministry for Foreign Affairs of Finland.

1.1 Objectives and structure

The objective of this report is to provide a general overview of the current state of urban planning, energy systems, water and waste management, transportation planning and a general awareness raising. One objective is also to provide some general information about what the EcoCity concept means in the Egyptian context. Some case examples are provided in order to give an idea of the practical conditions on the ground.

EcoCities in different forms and sizes have been implemented in different parts of the world. Ecological town planning has a long history. Terms such as "ecological town development", "sustainable city" or "solar city" became more common in the 1980's and 1990's.

An EcoCity essentially has high ecological quality, but at the same time it is technologically sophisticated and modern. The attempts to build an EcoCity so far have been based on optimization of different sectors or technologies and thus they strike a compromise between the high-level targets and present level of design. However, there is not just one EcoCity concept but a variety of possibilities that need to be adjusted so as to fit the local context, local culture and local economic realities. This is the way to achieve a possible solution with regard to the local resources, but at the same time meet the high goals set for an EcoCity. High-tech solutions are one way to the EcoCity, but they are not the only goal of an EcoCity.

As illustrated in Figure 1, the main elements of an EcoCity are a dense city structure, clean energy production, minimal energy consumption, sustainable transport solutions, ecological water and waste solutions and the inclusion of social aspects.

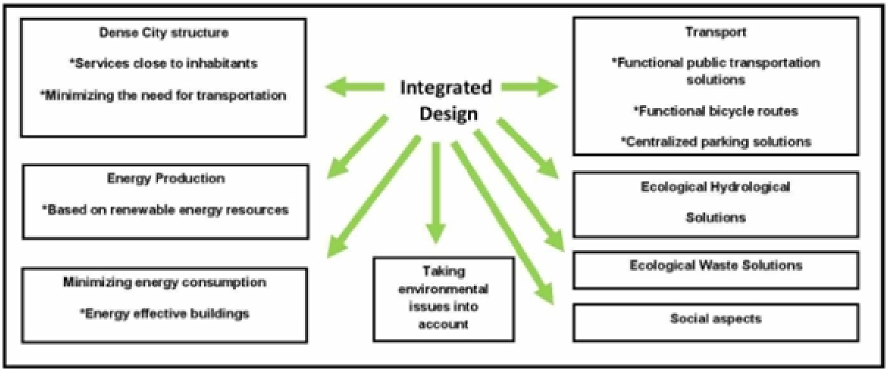

Figure 1. Main elements of the EcoCity Concept.

A dense city structure is essential in order to make it possible to provide daily services close to inhabitants and a functional public transportation system. These require a certain number of paying customers in order to be functional. Daily services are essential when minimizing transportation needs. In Egypt's bigger cities the city structure is often very dense. In high level luxury villa areas this might be an issue to consider, but mainly the city structure is already dense. This has been a natural process due to high population density.

When assessing energy production, there is not one single best solution available. It is always dependent on which energy source is the most suitable. In Egypt, different forms of solar energy have a high utilization potential. Wind conditions are also good in most parts of Egypt and provide good electricity production potential. The different energy solutions available are covered in Chapter 2.

Energy demand is reduced in buildings by different measures. In Egypt, the main emphasis is on reducing the cooling demand. Also hot water demand can be a significant contributor to the total energy demand. By different architectonic means, the cooling demand can be reduced a great deal without high investment costs. This is a talent that is traditionally quite well-known in Egypt. For thousands of years people have been forced to design their homes so as to keep the heat of the sun out. With modern cooling solutions there has been a slight change towards more careless designs and especially a more careless use of buildings, for example with doors and windows left open, letting the hot air in, while the cooling unit is working at full power to cool the room. These aspects are covered in more detail in Chapter 3.

Water solutions are a big issue in Egypt due to the scarce sources. There is room for many different water saving technologies on the market. Water treatment technologies are covered in Chapter 4.

Waste handling is one important aspect of the EcoCity approach. Proper waste handling can both save energy due to energy not being lost in handling unnecessary waste, as well as being an energy source. A sustainable waste handling system also lifts social wellbeing with less litter in the streets.

The use of private cars is a major issue in urban planning and in the sustainability of cities. Private cars use energy, produce emissions and cause noise. The infrastructure needed for the cars also takes a lot of space, leaving less space for the people in the city. Conflicts between allocating space for common green areas, and big car parks are not uncommon in urban planning. Too much traffic can also be a security issue. It can be concluded that fewer private cars lowers energy demand and raises social wellbeing in the city. This topic is covered in Chapter 5.

1.2 EcoCities and sustainability

Sustainable development refers to a form of development in which the use of resources meets human needs while preserving the environment so that these needs can be met not only in the present, but also for generations to come. The definition ties together a concern for the carrying capacity of natural systems with the challenges to human societies and addresses environmental issues.

The United Nations Commission Environment and Development famously defined sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (UN 1987). At the 2005 World Summit on Social Development, it was noted that this requires the reconciliation of environmental, social equity and economic demands that have been called the “three pillars” or “the 3 E’s” of sustainability (UN 2005).

Other systems of classification have been suggested in addition to the most widely used three pillars of sustainability. Atkisson & Hatcher (2001) proposed a sustainability compass, which uses a familiar compass format but converts the directions (north, south, east and west) into the four cardinal categories of sustainability performance: nature, society, economy and well-being. McCarthy et al. (2010) proposed circles of sustainability that include indicators for economics, ecology, politics and culture.

In the context of EcoCities it is also useful to introduce the concept of eco-efficiency. Eco-efficient communities aim at satisfying human needs in the community with as little environmental impact as possible (DeSimone et al. 2000). Mathematically this can be presented as the following equation (WBSCD 2000, Nikkanen & Lahti 2011):

$$\text{Eco-efficiency} = \frac{\text{Values of products and services}}{\text{Environmental load}} \tag{1}$$

Since the concept of creating a world that works both for nature and people was formally introduced to the world by the UN in 1987, sustainable development has gone through many ups and downs. It started to grow after the UN summits in Rio de Janeiro (1992), Johannesburg (2002) and Rio again ("Rio+20" in 2012). Initiatives such as the Local Agenda 21 movement for creating sustainable cities (which peaked in the late 1990s and early 2000s), the Decade for Education for Sustainable Development (which will conclude in 2014) and the spread of corporate sustainability reporting in recent years are all major milestones in a slow but global process of transformation to sustainability.

At the turn of the millennium, the United Nations set goals for the reduction of poverty all around the world. These "Millennium Development Goals," or MDGs, are considered by many to have been a remarkably successful strategy for mobilizing attention and resources. However, the work remains incomplete and the timeline set for the MDGs runs out in 2015.

At the global "Rio+20" summit, the world's nations agreed to renew and replace the MDGs with a new set of goals – goals that combine, for the first time, the dream of eliminating poverty with the need to safeguard the future of Earth's natural systems and resources. To be called the "SDGs", these new goals will be decided in 2014 and will come into effect in 2015.

Indicators of sustainability in EcoCities are clear and compelling measures of key trends in the economy, environment, social systems and human well-being. The primary purpose of indicators is to guide and stimulate action. Sustainability indicators, developed over the last ten years, attempt to bring all the important trends together, in one place, so they can all be considered together. In practice, sustainability indicators are tools for education, accountability and strategic planning. They provide feedback to both decision-makers and the public at large about past trends that are shaping the future. That is why sustainability indicators emerged as a "best practice" during the past two decades. They are used for understanding and managing improvement at every level, from neighbourhoods to nations.

1.3 EcoCities as ecosystems

An ecosystem is a biological environment consisting of all the organisms living in a particular area, as well as all the non-living, physical components of the environment with which the organisms interact, such as air, soil, water and sunlight. Urban entities (cities, towns and villages) are urban ecosystems. They are also part of larger systems that provide essential services that are often undervalued, as many of them are without a market value. Broad examples include: regulating (climate, floods, nutrient balance, water filtration), provisioning (food, medicine), cultural (science, spiritual, ceremonial, recreation, aesthetic) and supporting (nutrient cycling, photosynthesis, soil formation).

Like living organisms, cities (including their inhabitants) exhibit and require systems for movement (transport), respiration (processes to obtain energy), sensitivity (responding to their environment), growth (evolving/changing over time), reproduction (including education and training, construction, planning and development, etc.), excretion (outputs and wastes) and nutrition (need for air, water, soil, food for inhabitants, materials, etc.).

Cities concentrate people, enterprises, motor vehicles and their wastes. If planned in a sustainable way, a city brings many potential advantages for ensuring universal provision of infrastructure and services, keeping down waste levels, re-using waste water streams and de-linking a high quality of life from high level resource consumption and greenhouse emissions. These cities have economies of scale, proximity and agglomeration that bring substantial benefits for most businesses, and that is why urbanization is spreading. But less discussed are economies of scale and proximity to public goods and services.

High densities and large population concentrations usually lower the costs per household and per enterprise for the provision of infrastructure (roads, paths, piped water, sewers, drains, electricity) and services (healthcare, schools emergency services, etc.). The concentration of industries reduces the unit cost of making regular checks on plant and equipment safety, as well as on occupational health and safely, pollution control and the management of hazardous wastes. EcoCities have many potential advantages for reducing resource use and wastes. The proximity of water consumers gives greater scope for recycling or directly re-using wastewater. With regard to transport, EcoCities have great potentials for limiting the use of motor vehicles and the associated use of fossil fuels and generation of pollution, where short journeys may be made by walking or cycling and by a greater use of public transport for longer journeys. Integrated transport planning and provision of a good quality public transportation can significantly reduce private car ownership and use.

Valuable agricultural lands may be lost due to urban expansion. In EcoCities, it should be considered that demand for agricultural produce is a large part of the underpinning of farmers' incomes. In addition, most farmer and their families depend on markets, goods and services provided by urban enterprises.

1.4 EcoCities and governance

The change to an EcoCity does not happen by itself. Governance structures are needed to support the change, i.e. local governments and their relations to the population and civil society. Therefore, in EcoCities, there is a need for improved local governance. NGOs play a major role in raising the awareness of local populations about environmentally friendly practices and policies, and a commitment to supporting participation, and can also contribute innovations for realizing more accountable an democratic local governments.

So as to strengthen the social side of sustainable development, EcoCities should support the infrastructure and services in poorer areas that are not well-served, where lower income groups are settled, i.e. community development. NGOs have a lot to do in this area too. This would include the provision of drinking water, sanitation, drainage and garbage collection and programmes to improve schools and health care. This may include housing loans directed at low-income inhabitants so as to improve their housing conditions and provision of living facilities that address poverty and support environmentally friendly projects to generate solutions to improve their lives.

Developing EcoCities requires local changes and transformations of local community traditions and attitudes. Ultimately, it is the local community living the EcoCity that causes the human-induced environmental impacts such as pollution and greenhouse gas emissions. However, how the EcoCity is planned, managed and governed also has important implications for how it will cope with these environmental impacts. This vision needs the preparedness and capacity of all EcoCity dwellers and local government to work together to see and understand the potential that EcoCities can contribute to sustainable development. This calls for bringing together local governments, institutions, research and educational institutions (schools and universities), private sector and all stakeholders engaged in production to learn more and disseminate knowledge about the real meaning of sustainable development.

There is a strong link between quality of life in cities and how cities manage their natural resources. Resource efficiency entails the combination of greater productivity and innovation with lower costs and reduced environmental impacts, while providing increased opportunities for consumer choices and sustainable lifestyles. Therefore, transformation to resource efficiency resides in a range of factors such as redefining how urban systems are understood at the global level and developing a shared language for evaluating city sustainability indices that account for the sustainability of the cities (UNEP 2012).

In the transition to sustainability, a city needs to harness cooperation, political vision and leadership. Ways that can support the transformation towards EcoCities include the following:

1. Cities need to establish sector and institutional strategic intermediaries. These are institutions for education and higher education, research, policymaking and innovation, funding mechanisms, monitoring and auditing of governmental projects and non-governmental organizations and all other organs that play a role in ensuring bottom-up participatory governance in sustainability programmes bring about cross-sector and inter-institutional coordination.

2. The study of urban ecology, i.e. living with the approach and method of ecological research which means the study of habitats and habitat types that occur in specific cities, especially the urban spontaneous flora and fauna and vegetation. Humans and human activities are associated with prior specific location factors, but are not themselves the subject of research. Applications are made in terms of green planning and design in cities, to learn and experience nature and nature conservation in urban habitats. Nature in the city offers in addition to its intrinsic value ecosystem services to the inhabitants. Especially important is the function of plants,

especially trees. For this meaning spontaneously raised and planted crops are basically equivalent. Listed as essential functions are

- changes in microclimate mainly reduce heat loss by wind,
- filtration of aerosols and dust,
- soundproofing,
- the effect of recreation and well-being,
- the impact of parks, forests and wooded areas depends on their extent,
- individual trees and small green spaces improve the situation locally,
- extensive forest-like stocks can also affect the local climate in adjacent neighbourhoods.

3. The study of cities as ecosystems i.e. the viewing of entire cities with the approach and method of community ecology and ecosystem research. In particular, the context of ecosystem research, the identification of energy and material flows and balances of entire cities. A popular concept to illustrate this approach is the “ecological footprint” of a city. Questions of land use and indirect land use changes associated with all practices, e.g. biofuel production and associated green-house gas (GHG) emissions, should have priority through modelling, observations and experimental measurements. Soil erosion and degradation, maintenance of biodiversity, impact on water resources is to be included in the analysis.
4. As a part of city planning and development, the objective of an ecological or sustainable city has to be included, particularly to reduce the area and energy consumption and the creation of liveable neighbourhoods. The application of the campus concept as a tool would lead to the identification of the sustainability indicators required to examine the sustainability practices applied.
5. An early influential research direction within sociology, in terms of social needs, impacts, human rights measures, services provided, awareness programmes needed, dealing with crime and violence, measures of social capital and civil society, the social dimension, with activities including research in spatial, urban planning, impacts on health and awareness raising.

2. Energy systems

2.1 Oil and gas

According to the Oil and Gas Journal's 2012 estimate (Oil and Gas Journal 2012), Egypt's proven oil reserves are 4.4 billion barrels, an increase from 2010 reserve estimates of 3.7 billion barrels. New discoveries have boosted oil reserves in recent years. In 2011, Egypt's total oil production averaged around 710,000 bbl/d, of which approximately 560,000 bbl/d was crude oil including lease condensates and the remainder natural gas liquids (NGLs) (EIA 2013).

After Egypt's production peak of over 900,000 bbl/d in the 1990s, output began to decline rapidly as oil fields matured (Figure 2). However, ongoing successful exploration has led to new production from smaller fields, and enhanced oil recovery techniques in existing fields have eased the decline at ageing fields. In addition, output of NGLs and lease condensate has increased as a result of expanding natural gas production, and have offset some of the other declines in liquids production (EIA 2013) (see Figure 3).

One of Egypt's challenges is to satisfy increasing domestic demand for oil in the midst of falling domestic production. Domestic oil consumption has grown by over 30 percent over the last decade, from 550,000 bbl/d in 2000 to 815,000 bbl/d in 2011 (EIA 2013).

Natural gas has substituted for oil both in domestic use and in the export of energy. Production of gas has nearly tripled between 1998 and 2010. In 2010, Egypt produced roughly 63 billion cubic meters (bcm), exported 18 bcm and consumed 45 bcm (Razavi 2012). The electricity sector is the dominant gas consumer, accounting for 57 percent of total gas demand. The government has aggressively pursued the use of gas since the early 1990s, not only in power stations but also in industry. The industrial sector consumes about 11 percent of total gas consumption while fertilizer and cement industries are also large consumers, accounting for 10 percent and 8 percent respectively. The petroleum sector uses a substantial amount of gas for its own use and re-injection, accounting for 5 percent of total gas consumption.

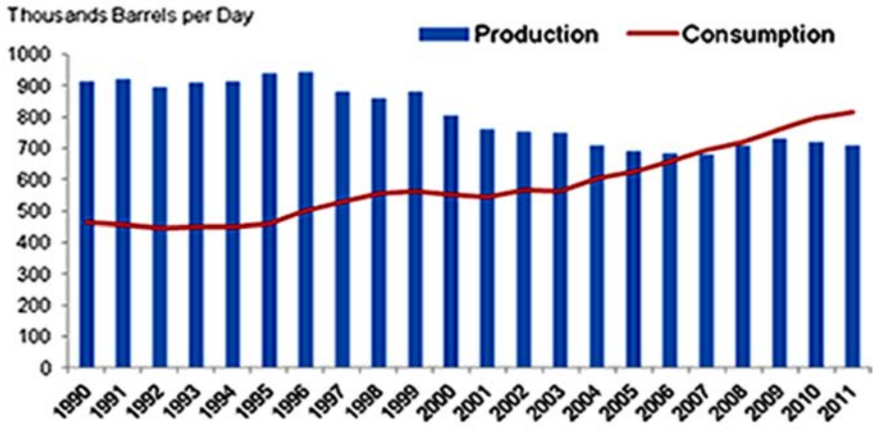

Figure 2. Total oil production and consumption in Egypt 1990–2011 (EIA 2013).

Gas is delivered to the residential sector through low-pressure pipeline distribution systems and in LPG (Liquefied Petroleum Gas) cylinders supplied by retailers. Combined, they account for 2 percent of the total gas demand but are expected to grow at a fast pace (about 15 percent p.a.). Finally, the use of compressed natural gas (CNG) in vehicles accounts for about 2 percent of total gas consumption; all taxis in the Cairo area must now run on CNG. Currently there are about 60,000 vehicles converted to run on CNG and Egypt now has the eighth largest CNG fleet in the World (Razavi 2012).

Since the early 1990s, gas reserves have quadrupled. According to the Oil and Gas Journal, Egypt's estimated proven gas reserves stood at 77.1 Tcf in 2010, making the country the third largest in Africa after Nigeria (185 Tcf) and Algeria (159 Tcf). The rise in gas reserves led Egypt to seek export options in the form of liquefied natural gas (LNG) and piped gas. There are three LNG trains in operation, though there is room to increase their throughput. Also Egypt now exports natural gas to Jordan, Syria and Lebanon through the Arab Gas Pipeline, with further planned connections to Turkey and Europe and to Israel through the Arish-Ashkelon gas pipeline (completed in 2008). Egypt exported 18.1 bcm of natural gas in 2010, around 70 percent of which was exported in the form of LNG and the remaining 30 percent via pipelines.

The rapid growth in internal and external demand for Egyptian gas has triggered some political sensitivity to further exports and a technical need to revisit the gas allocation policy. In particular, there is a concern about long-term availability of gas for Egypt's own future use. Export plans are supposed to be re-evaluated soon. A number of policy decisions have led to the prominent rise in domestic gas consumption in Egypt (see Figure 3). Although domestic gas prices were low, the government offered the upstream producers substantially higher prices in order to create the incentives necessary for upstream producers to develop existing reserves and explore for new gas reserves.

It is important to note that the government intends to phase out subsidies over time and has aggressively raised the price of gas to certain customer groups. The present price is $3.41 to $4.27/MWh for the power sector, $10.24/MWh for energy intensive industries and $5.8/MWh for other industries. In the residential sector the price remains between $1.71/MWh and $5.12/MWh.

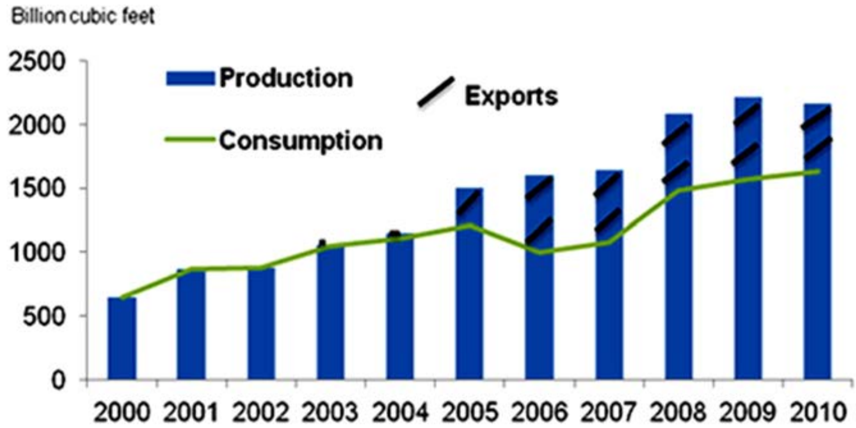

Figure 3. Natural gas production, consumption and export in Egypt 2000–2010 (EIA 2013).

In terms of electricity production, Egypt relies to a large extent on thermal power generation. Hydro power comes in second place, while the power obtained from renewable energy is still minimal. The total installed capacity in Egypt currently exceeds peak load, which means that the country is able to meet the demand for power through its own production, as shown in the table below. Table 1 shows the mix of power generation during 2008/2009.

Egypt has so far successfully managed to secure an electricity supply to 99.03% of its population. The electrical peak demand increased by an average of 7% over the last decade; it increased by more than 12% in 2007/2008. The peak demand has reached 23,000 MW in September 2009. To meet the increase in demand, an average annual expansion in generation and transmission as well as distribution of 2000 MW is needed over the next 20 years. The potential of adding more hydro-generation is limited. In 2008/2009 Installed renewable sources (mainly wind) has reached 430 MW, representing only 2% of the installed capacity, and energy generated from these sources represents only 1% of the electrical energy generated. In 2007–2008 an energy cost subsidy of 5.5 Billion LE was offered, mainly to the residential sector (El-Salmawy 2010).

Table 1. Installed capacity in Egypt vs. peak load 2008/2009 (Elshazly 2011).

Description [MW]	2008/2009
Peak Load	21 330
Hydro	2 800
Thermal	18 230
Wind	425
Private sector BOOTs (Thermal)	2 047
Total installed capacity	23 502

With respect to renewable resources, approximately 11.2% of Egypt's power comes from hydropower facilities, the first of which was built in 1960. This facility, the Aswan Dam, was constructed to control the Nile water discharge for irrigation. In 1967, the 2.1 GW High Dam hydropower plant was commissioned, followed by the commissioning of the Aswan 2 power plant in 1985, the commissioning of the Isna hydro power plant in 1993 and that of Naga-Hamadi in 2008.

The Egyptian household electrification rate in 2009 was approximately 99.6 percent, according to the latest estimates from the International Energy Agency (IEA). Although the country has one of the highest electrification rates in Africa, approximately 300,000 people still lack access to electricity, mainly in rural areas (EIA 2013).

Egypt's total electricity net generation was around 138.7 billion KWh in 2010, 124.3 billion KWh (90 percent) of which was from fossil-fuelled electric, 12.9 billion KWh from hydro and 1.5 billion KWh from wind. Electricity consumption has grown by an average of 7 percent annually between 2000 and 2010. Most of Egypt's power demand growth comes from the industrial sector. Ageing infrastructure and rising demand have led to intermittent blackouts.

Egyptian electricity consumption is increasing much faster than capacity expansions, and the government is planning to invest heavily in the power sector over the next decade, while also seeking financing from external sources. The private sector, international organizations and renewable energy funds such as the World Bank's Clean Technology Fund have all provided investment in the sector. Under existing plans, Egypt hopes to produce 12–20 percent of its electricity from renewable energy by 2020 while also developing a nuclear power industry, according to IHS CERA (EIA 2013).

The total installed capacity in Egypt currently exceeds peak load, which means that the country is able to meet the demand for power through its own production, as is shown in Table 1. However, if wind and hydro are considered only partially as firm capacity, there will not be a security margin left, which is a critical issue.

2.2 Hydro energy

Most of the available hydropower energy resources in Egypt are mainly located on the River Nile. They were largely exploited with the construction of the Aswan Reservoir, the High Dam and the Esna Barrage Hydropower Station, with installed capacity of 592 MW, 2100 MW and 91 MW respectively and representing total installed capacities of 2783 MW. There are 109 MW hydropower projects at Nagah Hamady and Assiut Barrages under construction on the main river. Small capacities of another 60 MW in total are also available at main canals and branches of the river. These capacities, which come to a grand total of 2952 MW, represent most of the available potential.

Government policy has consistently emphasized hydropower, but there is a view that most potential hydro resources have already been developed. Egypt's hydropower potential is about 3,664 MW, with an estimated energy of 15,300 GWh per annum (Elsobki 2007, NREA 2012).

There are currently five main dams in operation which are all located on the River Nile. Almost all the electricity generation comes from the Aswan High Dam and the Aswan Reservoir Dams. The Aswan High Dam power project has a theoretical generating capacity of 2.1GW, although low water levels often prevent it from operating anywhere near design capacity. An ongoing refurbishment programme is expected to extend the operational life of the turbines by about 40 years and increase generating capacity at the dam to 2.4GW.

2.3 Wind energy

Among other renewable energy resources, wind energy offers significant opportunities. Egypt is endowed with an abundance of wind energy resources especially in the Suez Gulf area which is considered one of the best sites in the world due to high and stable wind speeds. The West of Suez Gulf Zone offers the most promising sites to construct large wind farms due to high wind speeds, which range between 8–10 m/s on average, and also due to the availability of a large uninhabited desert area. There are other promising sites having wind speed of 7–8 m/s to the east and west of the Nile near the cities of Beni Sweif and Menia Governorates and El-Kharga Oasis in New Valley Governorate.

Some of the world's best wind power resources are located in Egypt, especially in the areas of the Gulf of Suez and West & East Nile Valley where at least 7,200 MW could be potentially developed. Wind resource measurements analysis and assessment have shown that the Gulf of Suez region enjoys considerable wind potential where wind speeds are ranging between 8.5–10.8 m/s with average yearly capacity factors ranging from 38% up to 60% or more than 5,000 equivalent hours, making that region among the best areas in the world for wind power generation projects. The Gulf of Suez is an arid desert area with no human activity except for some tourist villages and oil fields along the coast. The estimated potential is in the order of 20,000 MW installed capacities of grid-connected wind farms. Other locations in the Eastern and Western Desert of Egypt as well as Sinai Peninsula having considerable wind potential, even though less than that of Gulf of Suez, with wind speeds between 6–7.5 m/s, in addition to some locations around the Nile Valley with speeds of 7–8 m/s. The overall wind potential in such areas could reach 60,000 MW installed capacity.

The Egypt Wind Atlas (see Figure 4) was issued in December 2005 in co-operation with RISO laboratories of Denmark and Egyptian Meteorological Authority (EMA). It aims to indicate the areas with high wind speed which are qualified for wind energy projects (UNEP 2008).

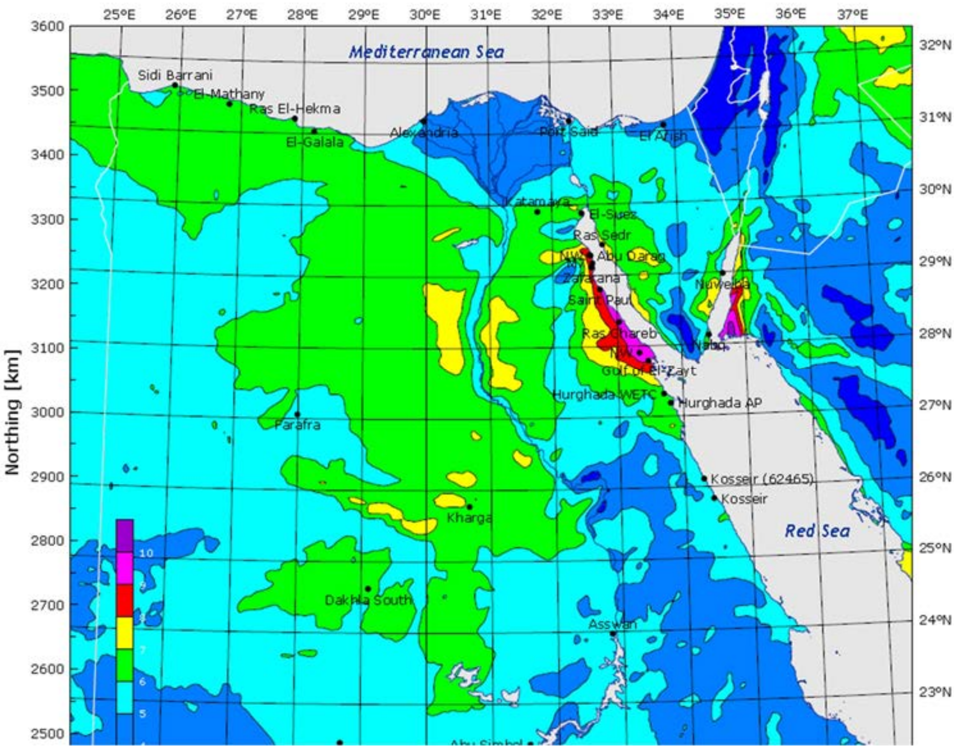

Figure 4. Wind atlas for Egypt (UNEP 2008).

The Atlas concluded that there are many promising areas with high wind speeds such as the Gulf of Suez, Some areas are located on both sides of the River Nile and some areas in Sinai. These areas are qualified for hosting the establishment of large-scale wind energy projects.

Egypt's progress in implementing wind power projects is rather impressive in the sense that the installed capacity is the largest in Africa and in the Middle East. However, the more impressive matter is Egypt's target and associated programme for future implementation. The government has set a goal of building about

7,200 MW of wind power capacity by 2020 (UNEP 2008; ElSobki 2007). The identified wind resources are considered sufficient to support such a target. The government has gone through extensive deliberations in order to determine the manner in which public and private investments should be mobilized to undertake the corresponding projects. In particular, the government has tried to minimize certain risks so as to facilitate the desert lands for future projects. The Land Use Agreement for the area assigned to each project will be signed with the investor free of charge (only actual expenditures will be paid after the project operation through instalment form 3 to 5 years). Other incentives for private investors include:

- The financial risk to investors is reduced by signing a long-term PPA (Power Purchase Agreements).
- The Government guarantees the financial obligations of the public sector.
- The electricity purchase price is expressed in foreign currency with a small portion relating to the local currency to cover local costs.
- Renewable energy equipment imports are exempted from customs duties.
- The project can benefit from carbon credits.

Worldwide, renewable energy has attracted a lot of attention and resources in recent years. As in the case of Egypt, the worldwide expansion of (non-hydro) renewable energy has thus far been focused on wind power.

2.4 Solar energy

Egypt is one of the sun belt countries that enjoys one of the largest potentials of solar energy. The solar Atlas was issued in 1991 (Figure 5), and the results of the Atlas shows that the average direct normal solar radiation is 2,000–3,200 kWh/m²/year. The sunshine duration ranges between 9–11 h per day from North to South with very few cloudy days (UNEP 2008).

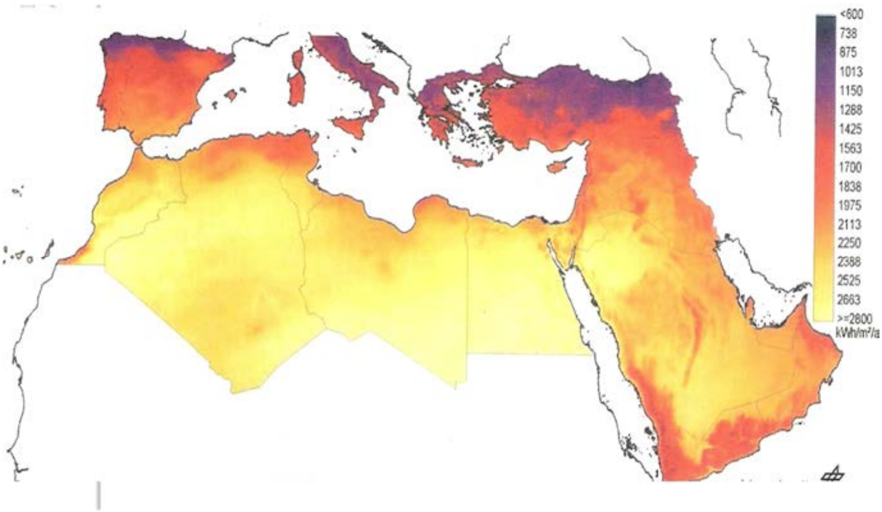

Figure 5. Direct normal irradiance in Northern Africa and the Middle East (DLR 2005).

2.5 Biomass energy

Biomass can generally be divided into four categories according to its origin: energy crops solely dedicated to bio-energy systems, post-harvest residues, organic by-products and organic waste (El-Dorghamy 2010). They are mainly of the following types, listed with examples found in Egypt:

- Agricultural residues (e.g. crop residues such as rice straw),
- Animal by-products (e.g. cow dung),
- Agro-industrial by-products (e.g. rice husks, bagasse),
- Exotic plants (e.g. water hyacinth, commonly known as Ward El-Nil, reeds, etc.),
- Oil crops (e.g. rape seed, Jatropha, etc.),
- Other crops (e.g. elephant grass, etc.),
- Municipal waste, which includes
- Municipal solid wastes (mixed with non-organic wastes),
- Sewage sludge.

Table 2 shows the quantity of waste by type in 2005, 2008 and 2013 (METAP 2005). However, for simplification, the bulk of the potential can be classified as agricultural residue, animal by-products, municipal solid waste and sewage sludge. This table shows how organic material is typically the main constituent, accounting for up to 60% of solid waste in Egypt, which is above the typical values in most countries and indicates its great value as a bio-fuel source. The amounts of MSW produced in Egypt are estimated to be more than 20 million tons/year, with the poorer cities generating the least. The lowest generating governorate is Fayoum. A recent study provided that MSW generation increases at a rate of 3.2% annually (METAP 2005).

Table 2. Quantity of waste generated in Egypt by type (METAP 2005).

Type of Waste	Estimated Averaged %	Quantity (million tons)		
		2005	2008	2013
Total Quantity of waste (above projetion chart)		17,5	20	22,6
Organic Waste	60	10,5	12	13,6
Paper and cardboard	10	1,75	2	2,25
Plastics	12	2,1	2,4	2,7
Glass	3	0,5	0,6	0,65
Metals	2	0,35	0,4	0,45
Textiles	2	0,35	0,4	0,45
Others	11	1,95	2,2	2,5

Power generation from gasification of sewage sludge in waste water treatment plants is already being used (for example, the El-Gabal El-Asfer 23 MW plant), with a potential generation of 1,000 MW from agricultural waste.

USTDA (US Trade and Development Agency) has provided $283,000 to Energy Allied Egypt to fund a feasibility study that will support the development of EBC Bio digesters project in Egypt. The objective of the project is to construct 10 bio digester units in six key locations throughout Egypt that will utilize agricultural, animal and organic solid waste for production of liquid and solid fertilizers and biogas for power generation. Implementation of the project will result in the offset of greenhouse gas emissions from existing landfills and unauthorized burns, and will represent a significant improvement over the current agricultural waste management practices in Egypt (USTDA 2013).

2.6 Egypt's renewable energy strategy

Egypt's Renewable Energy Strategy from 2008 marked a vital step in this effort, setting a target of reaching 20% of total electrical energy mix from renewable energy including hydropower by 2020. Taking into account current hydropower capacity (and projections for hydropower), it is expected that 12% of the contribution from renewable energy sources other than hydropower will need to be added by 2020 (i.e., equivalent to installed capacity of 7,200 MW) (NREA 2011).

The strategy identifies concrete steps, including large pilot implementation of solar projects and electrification of rural areas, development of mini and micro hydropower plants with a capacity of less than 100 MW, assessing potential for geothermal and developing 1,000 MW of biomass from agricultural and municipal waste. The Strategy also promotes the local manufacturing of renewable energy equipment, including incentives for activities supporting localization of renewable energy technologies. As part of its efforts to implement the Strategy, Egypt Era coordinates with Egypt's Industrial Modernization Centre, which is responsible for direct contact with manufacturers.

Initially under review in 2007, a proposed new Electricity Law is now "under ratification" and includes important market reforms such as the establishment of an independent operator, shifting from the single buyer to a bilateral market, third party access and priority dispatch for power generation from renewable energy sources. The proposed Law, while not final, is expected to pass largely in its current form. Considerable work has already been done by the regulator and others to ensure that the draft law's framework is supported upon adoption. In sum, there are four avenues by which renewable energy is now incentivized in Egypt; these are reviewed below:

- **Plants built through competitive bidding**: Under this approach, the grid operator will issue tenders requesting power supply from renewable energy sources, directed at large-scale installations (such as a 250 MW wind farm). These tenders will be designed to: control the increase in renewable energy capacity such that it matches the capacity of the transmission system and the capacity of the market to absorb the new renewable energy; increase local manufacturing; increase private investment; drive down costs, and provide the investors with guarantees through long term PPAs. The goal is to reach 2,500 MW in capacity through long terms PPAs, in blocks of 250 MW, targeting large international developers with strong financial status and high capacity for technology transfer. Evaluation criteria will include additional points for a high share of locally manufactured components. Egypt Era's role with respect to the competitive bidding process is to review power purchase agreements, issue licenses, help the investment review process and auditing.

- **Feed-in tariffs for smaller renewable energy projects**: Feed-in tariffs will be introduced for smaller capacities (less than 50 MW installations), again with a goal of reaching 2,500 MW capacity and will work in parallel with the competitive bidding process. The tariffs are to be set for 15 years and development of the tariff design and PPA contract is underway (15). As with the competitive bidding process, Egypt Era's role is to review power purchase agreements, issue licenses, help the investment review process and audit projects.

- **The Solar initiative**. Recognizing the natural resource potential, the Egyptian government has identified the growth of solar energy as a priority. Solar energy can benefit from the recently adopted European directive (2009/28/EC), which enables European countries to build renewable plants in a third country, providing that electricity will be physically exported to Europe. There are currently two regional solar initiatives that Egypt will be able to participate in, the Mediterranean Solar Plan and DESERTEC, though both are inhibited by existing limitations in transmission capacity. To accelerate the establishment of solar power implementation and mitigate the lack in transmission capacity in the short and medium terms, Egypt may need to consider alternative methods. One such option would be to export the quantity of natural gas equivalent to the electricity generated from renewable energy sources, while using the actual generated electricity from renewable energy domestically. Under the solar initiative, a registered and internationally recognized logo will be issued by the regulator which accredits solar energy consumers, offering holders better financing terms, export advantages and potential tax credits. Interested consumers will voluntarily commit themselves to consume up to 5% of their electricity from solar energy.

- **A Solar Energy Trader (SET)**: SET will be established to consolidate the committed inquiries and contract suppliers through long-term PPAs to satisfy these demands. SET will be owned and operated by a financial institution(s); committed consumers can have shares in SET, while suppliers cannot. Transactions will be conducted according to a feed-in tariff which will be a pass through cost to consumers. EgyptEra is expected to play a prominent role in:
    - Issuing the solar energy logo/certification
    - Developing a committed consumer register
    - Setting up mechanisms to guarantee consumer payments through electricity supply contracts and transactions between SET and distribution or transmission networks operators
    - Licensing SET and monitoring its operation to ensure transparency, free competition and non-discrimination
    - Issuing the solar feed-in tariff, approving the PPAs and ensuring their transparency
    - Licensing the solar energy producers; issuing certificates of origin
    - Ensuring third party access and priority of dispatching
    - Ensuring exemption from transmission or distribution fees as well as energy banking as a requirement for Public Social Obligation (PSO) of network operators
    - Dispute resolution
    - Hosting a steering committee of representatives of the stakeholders; the committee would promote the initiative among different business communities and refine it as well as follow up on its progress.
        - **Projects led by the New and Renewable Energy Authority (NREA)** (NREA 2012). Established in 1986, NREA is both a national agency for developing and planning the technology transfer and a developer that must seek and receive a license from the regulator in order to operate their new facilities. Construction is being completed on an integrated solar combined cycle power plant with 9,150 total MW, 30 MW solar) at Kureymat,

with $327.5 million financing capacity from the World Bank using the Global Environmental facility to offset the cost differential between solar and thermal resources and support from the Japanese Bank of International Cooperation and the National Bank of Egypt. In February 2010, NREA signed an agreement with Masdar of Abu Dhabi to build a 200 MW wind farm.

The draft Electricity Law also envisions a Renewable Energy Fund, derived from the state public budget, endowments, donations, grants and investments, which will provide support to purchase electricity from plants using renewable energy. The fund would cover: full or partial deficit between the renewable energy cost and market prices; exchange rate risk; guarantee of transmission company payments; financial support to pilot projects, and research and development of renewable energy technologies locally. The fund would be financed by the state budget, some proportion of the subsidies that currently go to existing energy industry, donations and ultimately investment fund money.

These policy and regulatory advances are matched by conditions that make Egypt particularly likely to fulfil its renewable energy objectives: a track record of bringing in large investment, a relatively large and stable economy for the region, a transport corridor location and potential; and its place as a leader in the region, making it able to spearhead regional initiatives, such as a Mediterranean super grid that would facilitate export of renewable energy.

2.7 Power generation costs

The rapid deployment of renewable power generation technologies and the corresponding rapid decline in costs are sustaining a virtuous cycle. The levelized cost of electricity is declining for wind, solar PV, concentrated solar power and some biomass technologies, while hydropower and geothermal produced at good sites is still often the cheapest way to generate electricity (IRENA 2012).

These technologies, excluding hydropower, typically have significant or even very high learning rates. Solar PV modules, for instance, have learning rates of between 18% and 22%. The rapid deployment of renewables, working in combination with the high learning rates for some technologies, has produced a virtuous circle that leads to significant cost reductions and is helping fuel the renewable revolution.

Renewables are, therefore, becoming increasingly competitive even on their own, but it is important to note that the analysis presented here excludes the impact of government incentives or subsidies, system balancing costs associated with variable renewables and any system-wide cost-savings from the merit order effect. Furthermore, the analysis does not take into account any CO_2 pricing or the benefits of renewables in reducing other externalities (e.g. reduced local air pollution or contamination of the natural environment). Similarly, the benefits of renewables being insulated from volatile fossil fuel prices have not been quantified. These issues are important, and if these were quantified would improve the economics of renewables for power generation. They are covered by other programmes of work at IRENA.

For renewable energy generation, cost ranges are typically wide and very site-specific. As a result, there is no single “best” renewable power generation technology. It is also important to note that distributed renewable technologies, such as rooftop solar PV and small wind, can provide new capacity without the need for additional transmission and distribution investment and, therefore, cannot be directly compared with large utility-scale renewable solutions where transmission and distribution costs of USD 0.05 to USD 0.15/kWh would need to be added.

Based on prevailing market rates, the levelized cost of electricity from solar PV in typical MENA climates is estimated as 15.4 US¢/kWh at an installed capital cost of $2.50/W. The price ranges from 12.6 US¢/kWh for a capital cost of $2/W (utility-scale projects) to 18.1 US¢/kWh at $3/W for roof-top installations (IRENA 2012).

Table 3 below shows the cost of electricity from solar PV (at $2.5/W) versus that for gas or oil-fired generation. Solar is cheaper than an open cycle peaking unit at gas prices above $17.07/MWh (equivalent to oil at around $30/barrel) but requires $58.05/MWh to be competitive with base load combined-cycle power – around current LNG prices. (ESIA 2012.)

MENA solar PV costs reach $2/W, or if the cost of capital is reduced to 4% then the break-even gas price falls below $34.14/MWh. In this case, solar power could potentially compete not only with oil and LNG, but also with imported pipeline gas or domestic unconventional gas (ESIA 2012). In practice, at different times of the day and year, solar PV will be replacing different types of generation and fuel. The optimal generation mix, shown in Table 4, minimizes the utility company’s discounted capital costs, operating costs and fuel costs. Life-cycle savings of solar power are shown compared to a generation mix using only oil and gas.

For fuel costs around $24.14/MWh, a modest amount (3–6%) of solar penetration in the energy mix is attractive only when capital costs or the cost of capital are low. However, for fuel prices around $54.63/MWh (similar to current LNG prices), large-scale solar penetration approaching 20% becomes economic, with lifetime savings of $1–2,000 million.

Table 3. Break-even price of fossil fuel at which solar becomes commercially viable (ESIA 2012).

Capital cost ($/W$_p$)	Cost of capital %	Break-even fuel price ($/MWh)
2.5	8	45.41
2.5	8	40.29
2	8	33.46
2.5	4	32.78
2	8	30.05
2	4	24.58

Carbon credits have not been included in this model but, indicatively, at $10/ton CO_2 each 1MW of solar installed would generate $10,000 in carbon credits resulting in a reduction of the break-even gas price by about $0.50/MMBtu (ESIA 2012). Other benefits of solar power may include reduced local air pollution, improved energy security, local employment and economic gains and reputational gains.

Table 4. Optimal generation mix (ESIA 2012).

Scenario					**Optimal solar generation**		**Life-cycle savings (million US$)**
Capital ($/W)	Opex ($/kWh/a)	Cost of capital	Legacy low-cost gas	Imported fuel price ($/MWh)	MW	% of total capacity	
2.5	30	8%	Yes	34.14	0	0	0
2.5	30	4%	Yes	34.14	700	6.3%	53
2.5	30	8%	No	34.14	0	0	0
2	30	8%	Yes	34.14	400	3.7%	9
2.5	30	85	Yes	44.39	0	0	0
2.5	30	4%	Yes	44.39	1600	14.1%	923
2.5	30	8%	No	44.39	1500	13.3%	196
2	30	8%	Yes	44.39	1500	13.3%	482
2.5	30	8%	Yes	54.63	1500	13.3%	364
2.5	30	4%	Yes	54.63	2900	22.9%	2462
2.5	30	8%	No	54.63	2100	17.7%	986
2	30	8%	Yes	54.63	2300	19.0%	1164

2.8 Regulatory status of the energy sector

Egypt has put in place a number of measures to reform the power sector from a vertically integrated state-owned monopoly into a commercially oriented flexible structure, although the transition has been gradual. A regulatory agency (the Egyptian Electric Utility and Consumer Protection Regulatory Authority – EEUCPRA) has been established to promote investments in the electricity sector by ensuring competition while at the same time taking care of the consumer’s interests. Egyptian Electric Holding Company (EEHC) has been unbundled, but operates as a tightly controlled holding company with strong links to the government, through subsidies, facilitation of investment financing, fuel prices and electricity tariff regulation.

EETC (Egyptian Electricity Transmission Company) functions as the wholesale single-buyer/single-seller of electricity, procuring electricity from generation companies and selling it to distribution companies and transmission network customers. All generation companies, including three BOOT (build-own-operate-transfer) projects, wind power plants and four industrial plants sell their electricity to EETC. The government is preparing the ground for advancing the sector reform further.

The new Electricity Law (which is not yet approved by the Parliament) introduces a number of changes toward strengthening the sector's commercial orientation and its opening to private investment and competition. It also addresses the promotion of renewable energy and energy efficiency. The law gives the authority for tariff regulation to the electricity regulatory agency, grants more independence to EETC, converting it to an independent system operator with open access for bilateral trading between generation and consumers, and promotes introduction of a competitive end-user market.

The main barrier to renewable energy in Egypt is that conventional subsidized prices adversely affect the whole spectrum of rational use of energy and renewable energy applications. Policies for price reform and restructuring are being considered by the government. They are indispensable if widespread use of rational use of energy and renewable energy is to be achieved. The means to overcome these obstacles are outlined below:

- Creating free markets which would stimulate private sector investment in wind energy would take some time, as subsidy removal is a sensitive issue that would take few years to create an actual impact. Accordingly, foreign financing assistance will continue to be needed during these years to keep the momentum for wind energy utilization and enable market liberalization smoothly.
- The electricity act presently under consideration should seriously consider the support of promising renewable energy technologies mainly through preferential tariff and/or mandated market share.
- Additional legislation of custom duties exemption and reduced taxation on renewable energy systems would prove economic feasibility and sustainability in the long run, in view of the long-term advantages of renewable energy (fuel saving and preserving strategic fossil fuel reserves for future generation and preserving the environment).
- Maximizing the use of CDM (clean development mechanism) and green certificate revenues to improve the economics of renewable energy systems.

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2.9 Policies and incentives

On 26/7/2009, the Supreme Council of Energy approved the following policies in order to stimulate and support generating electricity from wind energy (Razavi 2012):

- Approving private sector participation through competitive tender and bilateral agreements.
- Reducing project risks through signing long-term Power Purchase Agreements, PPA, for 20–25 years.
- The Government of Egypt will guarantee all financial obligations under the PPA.
- The selling price for energy generated from renewable energy projects will be in foreign currency in addition to a proportion that covers operation and maintenance costs in local currency.
- Investors will benefit from selling certificates of emission reduction resulting from the project implemented.
- Evaluation criteria for tenders of renewable energy projects will give privilege to local components.
- Exempting renewable energy equipment from custom duties.
- Obtaining all the permits required to allocate the land and clearing it from land mines
- Prepare the required studies for implementing projects such as environmental impact assessment including bird migration and soil research studies.

The land will be allocated according to the following conditions:

- Recapturing the land after ending the project life,
- NREA will restore the actual costs of preparing the land.

The investors will pay these costs in annual instalments covering a period of 3–5 years starting at the beginning of the project operation.

In Egypt, electricity prices to the end-user are subsidized by the government. Many gas and oil supplies are also subsidized – or set at regulated prices which are well below the import prices (if the fuel is imported) or the price at which that fuel could be exported. From the point of view of the utility, this may make solar power appear uncompetitive. But the provision of cheap fuel clearly represents a cost to the government, which has to procure that fuel. For residential/commercial (e.g. rooftop) installations, the subsidized pricing of grid electricity might make solar power artificially appear uncompetitive for property owners. Removal of electricity subsidies, or extension of those subsidies to solar power, can level the playing field.

The promotion of energy efficiency falls within the purview of the following agencies:

- Energy Supreme Council (ESC) (1979), it has been re-established in 2007
- Organization of Energy Planning (OEP) (1983), it has been dissolved in 2006
- New and Renewable Energy Authority (NREA) (1986)
- Council of Electricity and Energy Researches in the National Academy for Science and Technology (energy conservation branch) (1987)
- Egyptian Energy Efficiency Council (EEC) (2000)
- Electric Utility and Customer Protection Regulatory Agency (Egypt ERA) (2000)
- Energy efficiency unit in the Supreme Council of Energy (2009)
- The environment law does not include direct energy statements. However, it sets limitations for combustion emissions which have an impact on combustion efficiency. There are minimum energy consumption standards and labelling for some household appliances and an Energy Efficiency Building Code for both residential and commercial building.

In the electricity law there are the following energy efficiency promotion measures:

- The right to interconnect with the grid and a feed-in tariff for excess energy available from cogeneration.
- Each facility with a contracting capacity above 500 kW will have an energy manager as well as an energy register to monitor energy consumption by the facility.
- Transparent and non-discriminatory procedures for demand-side management bids as well as interruptible power contracts between transmission and distribution companies and their customers.
- Both transmission and distribution companies are requested to present an annual plan for energy efficiency on the customer side and demand-side

management to the regulatory agency. This plan can include, but is not limited to:

  - Demand-side management programmes
  - Energy efficiency programmes
  - Diffusion of renewable energy equipment (SWH, PV, etc.)
  - Customer awareness on EE.

- The government is requested to set the necessary plan to expand the energy efficiency labels and standards programme for equipment and appliances as well as set the necessary plan to phase out inefficient equipment. It is obligatory to put energy efficiency labels on all equipment and appliances for which an energy efficiency label has been issued.

3. Energy efficient architecture and planning

Urban planning is a political and technical process concerned with the development of the city and with the spatial and social structures in the city. It is concerned with the use of land and the eco-friendly design of the environment of a city, including transportation networks and sustainable energy. On this basis, urban planning develops conceptual plans, ideally with due consideration for all public and private interests with the aim of minimizing conflicts. It maps both public and private construction activity and controls the spatial development of infrastructure in the city. City planning controls, in the framework of development planning is essentially the use of land in the municipality. The task of urban planning is to achieve sustainable urban development of cities and municipalities and their subdivisions. Here, the social, economic and environmental problems and environmental jobs are to be reconciled into harmony. Socially equitable land use must be guaranteed.

Urban planning should help to ensure a decent environment, help protect natural resources and support the mitigation of climate change. Therefore, it is a basis for the development of sustainable future cities. In addition, the urban form and the local building culture and landscape are preserved and developed. Green space and landscaping are receiving increasing attention in the context of urban and rural planning and urban redevelopment. One way of achieving this is the Mixed-use zoning; i.e. avoiding separated zoning, single-use zoning for residences, homogeneous planning – which are monotonous.

The design of eco buildings refers to a way of designing buildings that takes advantage of the prevailing climate and natural energy resources, such as daylight, wind and thermal buoyancy, so as to achieve a comfortable environment while minimizing energy use and reliance on mechanical systems. Eco building design includes issues that are inherent to passive design for thermal comfort in hot and humid climates, namely the comfort zone, the minimization of cooling needs and techniques for cooling and dehumidification. Also, it highlights the need for acquiring generic design and control principles, which will help maximize the potential of various passive design techniques for providing thermal comfort in hot humid climates and which will also complement the knowledge already gained from case studies and fieldwork carried out in these areas. Furthermore, continuous research and development, both technical and commercial, are required in order to develop high-potential passive climate control techniques to become viable alternatives to mechanical solutions.

The eco building concept contains many sustainable techniques and technologies, including energy- and water-efficient landscaping, “smart building” control technologies, environmentally sensitive building materials, passive solar heating and cooling, advanced window systems and delighting, solar electric technology and electronic control systems. In brief, the concept contains sustainable building design principles and environmentally responsible living.

In what follows, various building elements are analysed. The aim of analyzing the building elements is for enhancing indoor quality, in order to have a minimal environmental impact made by the occupants of the building, protecting indoor environmental quality such as control fresh air and maximizing the amount of daylight let into the space. Also in order to avoid depletion of energy, water and raw materials by prioritizing environmental and life cycle considerations throughout all phases of architecture, design and construction, you can achieve all of your sustainability goals.

3.1 Spaces

Legislative boundaries to residential spaces are the following: the minimum inner height of a room is 2.70 m. The minimum inner width is 3.00 m. Minimum width for corridors is 0.90 m. A typical apartment has its windows and openings oriented towards the street, regardless of the orientation of likely wind blowing from the north-west. There is no ratio for room dimensions, which is related to sun angles or wind directions. For non-residential buildings there is no regulation for public spaces concerning width, heights and its three dimensions.

3.2 Orientation and shape of building

There is no regulation for building orientations related to sun angles or wind directions. The same applies to building shape. Buildings should be oriented in such a way as to optimize its heating or cooling needs and to allow in natural lighting according to recommendations. This can be done for example by orienting openings to the passage of the sun to maximize the amount of natural light throughout the interior spaces and reduce electric lighting costs. There is no regulation for material, colours, shading elements and windows. There is no regulation that compels the provision of effective shading or protection from a hot and humid climate.

The legislation states that the maximum built area is 60% of the plot, and the minimum green area is 40%. There is no ratio between building area and heights of building in urban spaces, which results in a huge area being exposed to direct sunlight in a hot region. In addition, there are no specifications concerning using building shadows in design. It is necessary to co-create with the environment and natural surroundings through using indigenous greener heat and storm water will be efficiently absorbed, reducing cooling costs and pollution runoff.

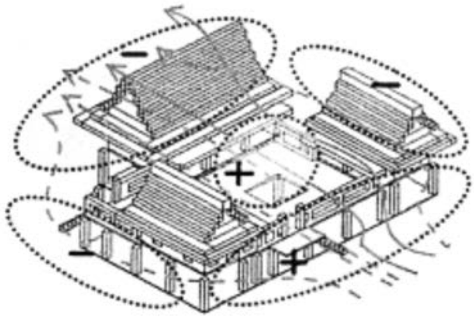

Figure 6. Defect orientation and spatial organization (Chenvidyakarn 2007).

Legislation for residential spaces:

- Windows throughout the area must over look roads, streets, or patios.
- Every room has to be naturally ventilated by at least one window.
- For living spaces[1]: window area > 8% of space area and a minimum of 1.00 m².
- For facilities[2]: window area > 10% of space area and a minimum of 0.50 m², minimum width > 0.50 m.
- If there is more than one window in one space, it is calculated according to the total area of all windows, but no window must be less than 0.50 m².
- Corridors, entrances, machine rooms and tanks do not have to be naturally ventilated.

Legislation for non-residential spaces:

- The legislation does not require any specifications for window shapes or area, because the non-residential areas are allowed to be artificially ventilated.

For residential and non-residential spaces there is no specification about the ratio between length and width, shape, orientations and lintel dimensions that help in environmental management. In addition, there is no code for widow specifications according to orientations (see Figure 7).

[1] Bedroom, living, dining, reception.
[2] Bathroom, kitchen, laundry.

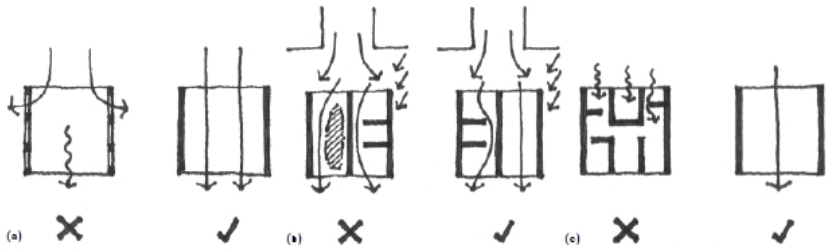

Figure 7. Examples of window design to encourage interior air movement (Chenvidyakarn 2007).

3.3 Patios

For residential spaces:

- Minimum width > 0.25 of building height[3], or 3.00m
- Minimum area > $(1/3)^2$ of building height.

Patios for facilities:

- Minimum width > 2.50m
- Minimum area > 7.5 m², if the building height is 10.00m
- Minimum area > 10.00 m², if the building height is 20.00m
- Minimum area > 12.50 m², if the building height is 30.00m
- There is 2.5 m² for every 10 m in height.

For non-residential spaces:

- could be artificially ventilated

For residential and non-residential spaces:

- The ratio between height and area (length and width) is according to sunlight and angle, which is good but it is not enough.
- There is no specification about the ratio between length and width, shape, orientations and lintel dimensions that help in environmental management.
- In addition, there is no code for widow specifications according to orientations.

[3] Building height at patios is measured from lowest windowsill.

3.4 Facilities

Legislation for residential spaces:

- Building must have one space for garbage.
- Every residential building has more than 10 apartments; it must have one security room.
- For residential spaces, there are no specifications about the dimensions of garbage space, or its devices or appliances.

For non-residential spaces, there are no specifications for facilities that help in sustainable systems inside buildings; such as devices or appliances that regenerate power or save rainwater.

3.5 Walls and roofs

For residential and non-residential spaces the legislation requires only one specification for roofs and walls, that is only safety and durability in use; it does not require any specifications that will achieve thermal comfort inside buildings.

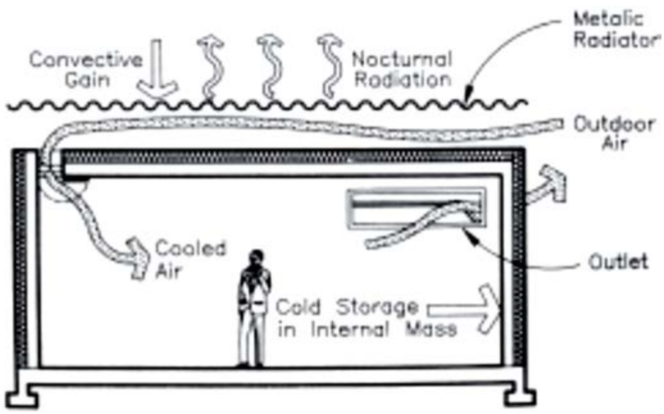

Figure 8. Schematic of a radiant cooling system which involves cooling the roof by nocturnal radiation and introducing cooled night air into the occupied space (Chenvidyakarn 2007).

Wall and roof systems should also be designed for optimum energy performance, including the use of multiple thermal breaks to help reduce energy use. There are no specifications about wall and roof section, materials, layers, gaps and thickness that influence indoor environmental quality.

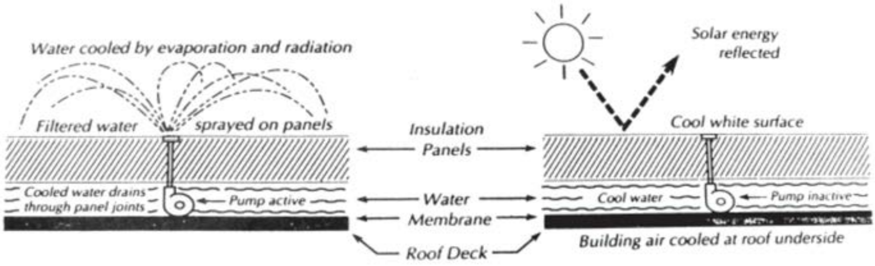

Figure 9. Example of a required system for roofs in order to achieve Indoor Environmental Quality. The left-hand side shows the situation during night time, the right-hand side during the day time. (Chenvidyakarn 2007.)

4. Water and waste management

4.1 Water management

Water availability is critical for industrial and agro-ecological production as well as for sustaining daily household activities. Water quality is also important for sustaining health, agricultural activities and ecosystem services. Population increase, rising living standards, over-exploitation, pollution, ecosystem degradation and adverse climate change effects all contribute to the water scarcity problem. Ensuring water supply and wastewater treatment in cities has also become a major challenge for cities that are experiencing high population growth levels. Cities are increasingly seeking out water from sources that are located even further away in order to meet the demand.

Waste water processing facilities are also under increased pressure in a number of cities, and the high cost of moving water-borne waste out of waste water facilities located far from the districts where the waste is produced, has become a major consideration for planners seeking new ways to address the challenges of waste water abstraction. Ultimately, however, there is a limit to the benefits that re-use and recycling can bring to a city water metabolism, and it is necessary for cities to be actively engaged in catchment scale management in order to improve their access to water in the long term. Water security challenges are not new to cities, but the increasing urban population pressure places huge demands on existing potable water provision and waste water abstraction processing plants. Cities in both the developed and developing world are extending their reach into ever-more remote locations so as to access water to meet the needs of their increases populations and production activities. Simpler and cheaper technologies which aid adaptation may find a greater uptake in developing countries, for example, rainwater capture, solar water heater, bio-bin composting and gas capture technologies. These can play a large role in shedding the load of conventional infrastructure systems.

Upgrading of existing water treatment is the first option for improving the potable water quality of the city. Moreover, it is necessary to treat intake water in order to prevent pollution. A monitoring program for a water treatment plant will be carried out so as to minimise the risks of water pollution and water-related diseases, for rational planning of pollution control strategies and their prioritisation and to assess the nature and extent of pollution control needed in water bodies The programmes will also evaluate the effectiveness of pollution control measures already in existence, evaluate water quality trend over a period of time, increase understanding of the environmental fate of different pollutants, assess the assimilative capacity of a water body thereby reducing cost on pollution control and assess the fitness of water for different uses.

Some industries in Egypt treat or recycle generated industrial wastewater in compliance with environmental laws and regulations (EEAA 2007). Others, however, continue to heavily pollute waterways and water resources. Toxic industrial wastes have been observed accumulating in river sediments near factories. The industrial sector represents 26% of Egypt's gross domestic product, and the number of industrial enterprises is estimated at about 22,000 (EEAA 2007). The industrial sector contributes to environmental degradation in Egypt to a substantial extent. The intense concentration of industrial activities in urban areas and the use of relatively old technologies have resulted in severe problems such as depletion of natural resources, air and water pollution, weakening of agricultural productivity and threats to public health.

4.2 Waste recycling, treatment and vaporization

Solid waste management has the potential to contribute to reduced landfill demand, reductions in green-house gases, lower terrestrial and aquatic pollution levels and reduced energy use in the transport and disposal of wastes. Recycling and reuse of wastes has the potential to create jobs and reduce dependence on material import for production. Waste management challenges in cities are amplified by high rates of urbanization. City governments are increasingly recognising and attempting to deal with the polluting effects of landfills on surrounding areas and the water table where landfill sites are improperly managed. This is especially the case in the developing world.

The total annual municipal solid waste generation in Egypt has increased more than 36% since 2000, to the current level of 20.5 million tons per year (2010) (SWE 2010). The severe water and air pollution, which is causing the most environmental damage, is mostly attributed to uncontrolled burning of municipal solid waste, agricultural residue and disposal of wastewater into water streams. Open burning of municipal solid waste and agriculture residue alone has been estimated to account for 42% of annual air pollution (EEAA 2006). Yet difficulties in management and lack of incentives have hampered efforts to address this problem. However, bio-wastes can in many ways become a valuable product if proper methods for material and energy recovery are followed, such as recycling and/or using bio-waste technology for generating H_2, biogas, heat and electricity (Tawfik et al. 2013). Therefore, prospects for the increased use of clean energy may promise better environmental conditions in Egypt, while reducing greenhouse gas (GHG) emissions (Barakat et al. 2003). Furthermore, on a strategic planning level, introducing bio-energy technology in Egypt will create valuable opportunities for further savings on energy and material otherwise wasted, since even municipal solid wastes and food wastewater industries mainly consist of biodegradable organic matter. The realization of this potential synergy between benefits in energy, local and global environment, socio-economic development and other aspects of sustainable development, is the motivation for developing EcoCities.

Today, the public health, environment, economy and cultural heritage of Egypt are all strongly affected by the severe impact of challenged environmental management and high population density, which is already affecting the quality of life of its inhabitants and threatening a healthy life for future generations. This comes at a time when Egypt is rapidly approaching dependence on foreign energy sources (DGS 2005). Utilizing these "wastes" as a resource, or fuel, for bio-energy systems would entail many environmental and developmental benefits (DNA 2007). As the population of Egypt continues to grow, approaching 88 million citizens, and resources for energy and materials deplete, renewable energy becomes key to sustainable development (World Bank 2002). Several researchers have referred to the vast potential of bio-waste resources in Egypt and the potential for promoting local development and environmental sustainability through growing this strategy (waste to energy).

The solid waste management (SWM) sector suffers from several problems. Options for improvement and development of the sector are as follows:

Strategy and planning

- Developing and implementing a policy aiming to reduce waste generation.
- Establishing a programme for source separation.

Legal framework

- Establishing a national SWM law.

Private sector participation

- Adapting suitable mechanisms to enhance private sector participation in the ISWM system, which is a main policy of the national strategy.
- Finding a suitable mechanism to integrate the informal sector "zabbaleen" trash collectors in the privatization process.

Finance and cost recovery

- Application of the 'polluter pays' principle, which is another policy of the strategy, in addition to the 'extended producer responsibility' principle, recommended by the strategic framework for enhancing solid waste recycling.
- Allocating an annual budget by the central Government for the SWM sector until a sufficient cost recovery mechanism is achieved.
- Budgetary allocation of investments to remove waste accumulations, improve collection and transfer, establish transfer stations and recycling

centres. Supporting SWM projects that reduce emissions of Greenhouse Gases (GHGs) to receive carbon credits, using the CDM/PCF (prototype carbon fund) and GEF (global environment facility) mechanisms.

Management and monitoring

- Establishing a monitoring and evaluation system in cities for the SWM with specific roles and responsibilities.
- Improving managerial and marketing staff skills.
- Applying accurate techniques for measuring the annual generated quantities of the different types of waste.

Training and capacity building

- Implementation of capacity building and training programmes for the governorates' staff in planning, contracting, implementation, monitoring and follow up of SWM services.
- Establishing a capacity building programme and action plan to integrate the technical, conceptual and social skills required to facilitate multi-stakeholder participation.
- Implementation of training programmes for human resource development of the labour responsible for maintenance and repair of equipment.

SWM enhancement

- Increasing the efforts for removing the accumulated solid waste.
- Extending SWM services as a priority and involving NGOs and local contractors.
- Reducing the gap between the current performance and the strategy targets by: improving the collection coverage; closing the existing dumping sites and enhancing waste recovery procedures; and adapting source separation and source reduction mechanisms.

Waste valorisation

- Developing the recycling sector by establishing central recycling centres at the national level and setting up national standards for the recycling industries and products.
- Adapting new waste utilization technologies such as, hydrogen, biogas and waste-to-energy projects.
- Establishing recycling centres for e-waste, using proper treatment technologies.

Public awareness

- Establishing a communication strategy and action plan to raise awareness and community participation.
- Launching public media campaigns to raise awareness on hazardous household waste and e-waste.

4.3 Case example: New Borg El Arab City

Borg El Arab City (NBC) is one of the recently established cities in Egypt, created by presidential decree (506/1979). The total area of the city is 47 500 acres, of which 26 700 acres are built-up area. Its current population is 150 000 inhabitants; the population is expected to reach 570 000 inhabitants by 2022. Borg El Arab City is located 60 km west of Alexandria and 7 km from the Mediterranean shore. The city is today mostly an industrial city with most workers commuting from Alexandria.

4.3.1 Potable water

The city has a water treatment plant with a capacity of 166,000 m^3/day. The treatment is composed of a pre-chlorination step followed by a coagulation process using alum ending in a sand filtration unit. The intake of the water treatment plant is mainly from the Mariout canal. If the intake is not enough, extra intake from Nubariya canal is frequently used. The quality of the potable water of the city does not comply with World Health Organisation (WHO) and Egyptian standards (ministerial decree, 2006) for human use. The whole population of the city normally use onsite membrane filtration for further purification of the water. This is mainly because the intake of the water treatment plant is polluted from different sources such as industrial, domestic and agricultural wastewater. Therefore, pollution control and prevention of the intake of water is required to improve the efficiency of water treatment plant.

4.3.2 Domestic and industrial waste water

A sewage system of 562 km length has been established together with a sewage treatment plant (oxidization plant only) with of 36,000 m^3 capacity. The industrial wastewater is facing some problems because of lubricants and factory wastes dumped in sewage and the availability of the final treatment unit.

The number of working factories in New Borg El Arab's industrial zones has increased from 279 to 411 over the past four years. The City Development Agency and the Board of Trustees of New Borg El Arab are making the greatest possible efforts to improve the existing services and add new services to absorb the current and expected increase of residents and industrial activities over the coming years.

Thus approaches by management to the expected increase in residents and industrial activities over the coming years must be viewed in the broader sustainable development context by providing the opportunities for local communities to utilize the precious water resources to its maximum potential, while maintaining and conserving the environment within Borg El Arab City.

Some industries in New Borg El Arab partially treat or recycle generated industrial wastewater in compliance with Egyptian standards (Ministerial Decree no 44 for year 1994). Others, however, continue to heavily pollute water resources.

Unfortunately, there is no data for either industrial solid waste or for wastewater. However, the mixture of domestic sewage and industrial wastewater is currently treated at a waste stabilization pond (Figure 10) with a capacity of 40,000 m^3/d and the plant effluents are used for irrigation of the forest. The treatment plant consists of 2 ponds. Each pond comprises 9 facultative ponds, arranged in 3 parallel series (Figure 11). The retention time is 6 days in each facultative pond and 3 days in each maturation pond. The plant is hydraulically and organically overloaded, which has a negative effect on the efficiency of the treatment plant. The percentage removal of BOD, COD, SS and NH4-N are only 57%, 56%, 44% and 39%, respectively for the first complex and 21%, 42%, 39% and 25%, respectively for the second one (Hussein et al. 2005). Faecal coliforms are reduced by about 1 log 10 units in both complexes. Based on these results, the final pond effluent does not comply with the Egyptian law for reuse in irrigation. The main reasons for the deterioration of the wastewater treatment plant are that 64 factories are discharging industrial wastewater, including 9 textile plants, 11 fabricated metal plants, 7 paper and cardboard plants, 12 chemical plants, 23 food industrial plants and 2 glue plants. Additionally, 39 factories are violating law 93/62 for wastewater discharge into the sewerage system for one parameter or more.

Figure 10. Picture of a waste stabilization pond (40,000 m^3/d) for treatment of mixed industrial and domestic wastewater.

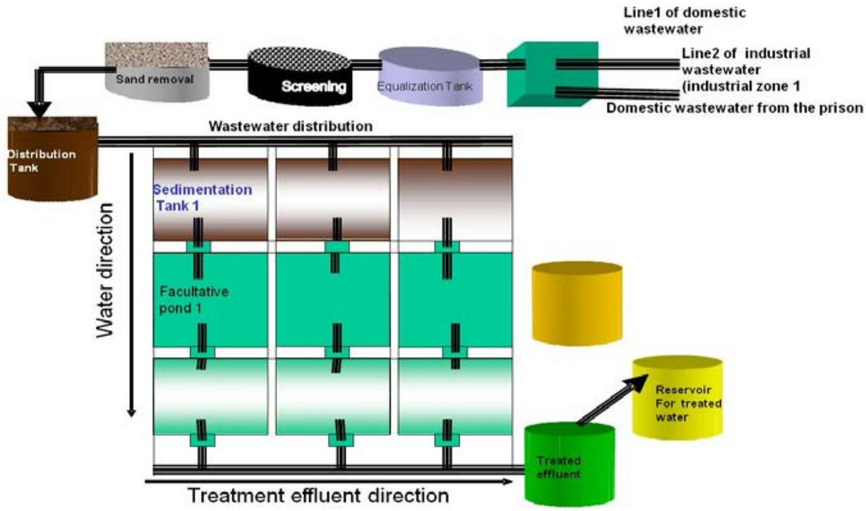

Figure 11. Layout of the waste stabilization pond (WSP) treating the mixture of domestic and industrial wastewater (industrial Zone no.1).

Fortunately, some biodegradable carbohydrate, protein containing and non-toxic industrial solid wastes such as potato, soybean, milk processing, whey, olive mill, baker's yeast and sugar cane can be used as a raw material for clean energy production.

4.3.3 Solid waste management

Municipal solid waste (MSW) is primarily waste which is produced by the household in New Borg El Arab city, but also includes some commercial and industrial waste that is similar in nature to household waste and has been valorised by the Nahdat Misr Company. The organic fraction of municipal solid waste is mainly used for composting. MSW can be a liability if requiring disposal but also represents a considerable resource that can be beneficially recovered, for instance by the recycling of materials such as aluminium cans, metals, glass, fibres, etc., or through recovery operations such as conversion to energy and composting. The total annual municipal solid waste generation in New Borg El Arab city has increased more than 36% since 2000, to the current level of 20–25 tons per day (Nahdat Misr company). Table 5 shows the estimated breakdown of MSW generation at New Borg El Arab city. Table 5 shows how organic material is typically the main constituent, up to 60% of total municipal solid waste in the city. Clearly, new waste management practices are needed. When it is economically viable and environmentally sound, recycling of materials is preferable to treatment for energy recovery. In practice, however, even in countries with a highly developed recycling infrastructure, significant tonnages of MSW remain after recycling to make energy recovery an environmentally justified and economically viable option – ahead of final disposal to landfill. Research, demonstration and dissemination are now focusing on the balance between waste minimization, material recycling, energy recovery and landfill of the non-biodegradable fractions. Typically, a ton of MSW has about one-third of the calorific value of coal (2.22–3.33 kWh/kg as received for MSW and 6.94–8.33 kWh/kg for coal) and can produce to about 600 kWh of electricity.

Table 5. Typical municipal solid waste composition in New Borg El Arab City (Nahdat Misr Company 2012).

TYPE OF WASTE	PERCENTAGE (%)
Organic	50–60
Paper and carton	12–26
Plastic	2–10
Glass	1–4
Rags	1.8–8
Other materials	8–20

5. Transportation

It is a challenge to keep the infrastructure of a city apace with the needs of its citizens. More flexibility and functionality is needed, otherwise quality of life will suffer in a growing city. New mobility and urban mobility concepts are needed that combine different offers such as rental bikes, railways and electric cars. There is also the question of how much mobility is needed in a modern city? The aim should be to bring living and working closer to each other.

Since cities are the centre of life and are the engine of the economy, urban mobility is a key factor. Urban mobility, especially sustainable mobility, in the city that allows people to move freely and safely, while taking the environment into consideration at the same time, is of great importance to our quality of life, our health and our economy.

A good combination of different modes of transport, convenient parking facilities outside city centres, the introduction of road pricing, better traffic management and better traffic information, carpooling and car sharing and efficient transport of freight could help to reduce traffic jams. Transport involves considerable amounts of carbon dioxide emissions, air pollutants and noise that harm the environment and human health. The development of clean energy efficient transport technologies and the establishment of "green zones" (with pedestrian zones, access restrictions and speed limits) are only a few of the options for cities to become environmentally friendly. Energy-efficient driving and an environmentally conscious procurement could also help to overcome these challenges.

Intelligent Transport Systems (ITS) and good traffic management can help to increase efficiency through smart charging, smart ticketing for public transport and better passenger information. Another challenge is to make public transport more accessible to all citizens. Society is changing. It is ageing and expects flexible, affordable and convenient solutions for mobility. We want to have seamless, secure and efficient urban mobility solutions for goods and people. This requires good links between the various transport modes and also between the transport networks of the inner cities and those in the suburbs, for example by establishing park and ride locations outside the cities. People should be at low risk as they move through the city.

The action to be taken is to address specific areas within the multidimensional nature of developing sustainable transport. These actions range from research on energy efficiency, fuel consumption and on a better understanding of how alternative/advance vehicle concepts (e.g. hybrid, electrical, and hydrogen fuelled vehicles) and alternative fuels may contribute to alleviating pollutant sources and thus reduce negative impacts on the environment. The action should also assess different transport and environmental strategies and policy measures in the transport sector.

In order to achieve a remedy in this context, we need to explore questions regarding mobile behaviour, vehicle technology and infrastructure requirements. Consistent enforcement of traffic regulations is essential in this context. Moreover, due to the fact that citizens do not feel safe while using public transportation, which in turn can prevent a decline in the use of privately used vehicles, cities need to work on safety requirements so as to protect people from criminal or terrorist acts while using public transportation. Facing these challenges also means that we have to change our behaviour and create a new culture of mobility, in which all possible parties are involved in the process.

Sustainability of the transport system is also a focus, with activities concentrating on transport emissions and their impact on the environment. With regard to the development of sustainable transport, areas such as the ones below should be considered:

- the environment with research on emission control and related impacts on ecosystems and the development of vehicle emission standards;
- the potential to reduce emissions by emerging technologies under different policy scenarios;
- the techno-economic dimension with research on the assessment of externalities, improved fuels and engines, alternative vehicles concepts and the impact of innovation on competitiveness and economic growth as well as assessments of transport policy options;
- the activity of studying the current and future prospects of low carbon energy supply and demand technologies and their impacts and interactions within the future energy system as they advance from concept to commercial applications;
- the definition, analysis and testing of sustainability criteria for biofuels production and use. The work will concentrate on the sensitive areas of the production systems which require specific attention from a scientific but also policy point of view.

5.1 Transportation and environment

5.1.1 Air pollution

Air pollution can be defined as any atmospheric component which adversely affects human health or public welfare. The effects of air pollution cover the whole range of spatial sizes, from local to global. On the local scale (single streets, urban areas, railway stations, etc.), pollution affects public health and the quality of life. Regionally, pollution affects plants and the built environment, through the dispersion, deposition and chemical transformation of the pollutants (photochemical reactions and acid rain). Globally, pollution is related to climate change and the depletion of the stratospheric ozone layer. Table 6 schematically presents the extent of the various pollutant effects.

Table 6. Impacts of transportation sector related air pollutants (Shahin 2001).

Pollutant	Impact type					
	Local		Regional		Global	
	High Concentration	Acidification	Photochemical Oxidants	Indirect Greenhouse Effect	Direct Greenhouse Effect	Stratospheric Ozone depletion
Suspended Particulate Matter	■		■			
Lead (Pb)	■					
Carbon Monoxide (CO)	■		■	■		
Nitrogen Oxides (NO)	■	■	■	■		■
Volatile Organic Compounds	■		■	■		
Tropospheric Ozone (O_3)		■	■	■		
Methane (CH_4)				■	■	
Carbon Dioxide (CO_2)					■	
Nitrous Oxide (N_2O)					■	
Chlorofluorocarbons (CFCs)				■	■	

Fuel combustion is the largest single contributor to air pollutant emissions. Stationary and mobile sources (internal combustion engines) are responsible for approximately equal overall shares, varying significantly, for individual pollutants. Stationary sources refer to human activity sectors such as industry, agriculture, energy, etc., whereas mobile sources refer to transport activities such as motor vehicles, aircraft, ships, railways, etc.

Air pollutants caused by the transport sector include both pollutants directly emitted by the use of vehicles (such as CO, NO_x and hydrocarbons) and secondary pollutants formed by chemical reactions in the atmosphere (such as photochemical oxidants). Pollutants commonly involved are the following:

- Carbon monoxide (CO) results from incomplete combustion, is an odourless and almost colourless gas. It interferes with the absorption of oxygen by haemoglobin (red blood cells) producing carboxyl-haemoglobin and thus restricts the supply of oxygen by the blood to body tissue. Carbon monoxide in urban atmospheres has been linked to loss of worker productivity and general discomfort. It affects the central nervous system, impairing physical co-ordination, vision and judgment.
- Nitrogen oxide (NO_x) formed by the combustion of fossil fuels, particularly diesel, has a variety of direct and indirect effects on human health and public welfare. Nitrogen Dioxide (NO_2) is of great concern with respect to human health; acute exposure to NO_2 reduces gaseous exchanges in blood and increases respiratory symptoms producing lower lung function values. These effects can cause irritation and eventually lead to pulmonary oedema. NO_x emissions are an important precursor to acid rain, which may affect both terrestrial and aquatic ecosystems. This effect is even more pronounced when nitrogen dioxide and sulphur dioxide (SO_x) occur simultaneously. Together with SO_x they participate in the formation of atmospheric acids and therefore contribute in large part to acid deposition.
- Lead (Pb) results from fuel lead which is added to attain the desired octane rating in petrol, and has long been known to damage the kidneys, liver, reproductive system, blood formation, basic cellular processes and brain function at relatively high levels in humans.
- Lead enters the body primarily by absorption of ingested lead from the gastrointestinal tract and by absorption of inhaled lead from the lower respiratory tract. Studies have been carried out to quantify the effects of petroleum lead on human health, particularly on that of children. It has been found that both average blood lead levels and cases of lead poisoning in children correlate strongly to petroleum lead. Because of this close relationship, reducing the lead content of petrol has been demonstrated to significantly reduce the health risks in urban areas.
- Sulphur dioxide (SO_2) resulting from the combustion of fossil fuels, particularly oil and coal which contain sulphur compounds, is a strong irritant to eyes and mucous membranes. With particulate it can form sulphuric acid (H_2SO_4) in lungs or as the main constituent in acid rain.
- Volatile organic compounds (VOC), including the entire class of hydrocarbons, are found in exhaust emissions or arise from spills and leaks of liquid or gaseous fuel, and have long been considered traditional air pollutants because of the role they play in photochemical oxidant formation.

Low-molecular-weight hydrocarbons are relatively non-toxic, but at relatively high concentrations can cause unpleasant effects, which may include eye irritation, coughing and sneezing, drowsiness and symptoms akin to drunkenness. On the other hand, heavy molecular weight hydrocarbons cause more serious risks to human health even at relatively low concentrations. Some studies showed that some organic compounds may have carcinogenic or mutagenic effects. Benzene, for instance, as a constituent of gasoline and automobile exhaust gas, is a known human carcinogen, causing leukaemia.

- Fine particulate matters consist of small solid or liquid particles of varied chemical composition suspended in the atmosphere. They may be toxic in themselves or may carry toxic (including carcinogenic) trace substances adsorbed to their surface. Because of their small size, they remain suspended in the air for a long time and can penetrate deep into the respiratory system, irritating lung tissue and causing long-term disorders. In urban areas, a strong correlation has been established between suspended particulates and variations in infant mortality and total mortality rates. Diesel particulate emissions are extremely small, and therefore of special concern because they are combined with toxic compounds with potential carcinogens.

The relative contribution from motor vehicles to deteriorating air quality in cities is higher than its share on a national basis. In large city centres, road traffic may account for as much as 90 to 95 percent of lead and carbon monoxide, 60 to 70 percent of oxides of nitrogen and hydrocarbons and a major share of particulate matter (Litman & Burwell 2006). These excesses are damaging to health, especially to pedestrians and those living or working in the open on traffic thoroughfares.

It should be noted that, while local conditions have improved recently in many developed countries, those in many developing-country cities have continued to decline. The air quality in the major cities of developing countries is already as bad as or worse than that in cities in developed countries (Table 7). Environmental studies show that air pollution in developing countries accounts for tens of thousands of excess deaths and billions of dollars in medical costs.

Lead concentrations in some areas of Cairo are five to six times higher than the global norms of the World Health Organization (WHO), which results in the lead content in the blood of children in Cairo being three to five times higher than that of children in rural Egypt (Cohen et al. 2004).

Table 7. Ambient air quality indicators for some cities, average mean concentration (Shahin 2001).

City/Emission	Pb	CO	NO_2
Bangkok	⊗	○	○
Cairo	●	⊗	NA
Jakarta	⊗	⊗	○
Berlin	○	⊗	○
London	○	⊗	○
Los Angeles	○	⊗	⊗
Mexico City	⊗	●	⊗
Moscow	○	⊗	⊗
New York	○	⊗	○
Sao Paulo	⊗	⊗	⊗
Seoul	○	○	○
Tokyo	NA	○	○

● WHO guidelines exceeded by more than a factor of two
⊗ WHO guidelines exceeded by a factor of up to two
○ WHO guidelines normally met
NA Not Available

5.1.2 Climate change

The global impacts of air pollution is the greenhouse effect, caused by certain gases and possibly affecting the world's climate and causing damage to the stratospheric "ozone layer", potentially a health hazard. The Earth's atmosphere has been transformed slowly, as human activity has pumped into it billions of tons of greenhouse gases (GHGs) such as carbon dioxide and large amounts of other gases that absorb the heat energy emitted from Earth's surface.

The principal force driving Earth's weather and climate change comes from the Sun. Although the Earth receives only about one two-billionth of the energy emitted by the Sun, this energy is enough to heat the Earth, drive ocean currents and create weather patterns. The heat output of the Sun has varied by about one-third since life on Earth began, and continues to vary during the solar cycles.

During the past decade or so, people have become concerned with how human activity may be affecting the world's climate. This concern has focused largely on GHGs which are generated by human activity such as the combustion of fuel for transportation. GHGs intensify the natural greenhouse effect because they absorb infrared radiation emitted from the Earth, increase clouds and rain. GHGs occur naturally in the atmosphere and are essential to life on Earth in its present form.

The concern is that human activity may be increasing the concentration of atmospheric GHGs enough to alter the climate.

Climate change is in part caused by emissions from transportation. Figure 12 illustrates the phenomena of the creation, prevent and adaptation of global warming. The enhanced use of best available technologies, such as new vehicle technology, alternative fuels and environmental transportation planning could help to prevent climate change through reducing the use of fossil fuels and GHG emissions. In addition, the adaptation of particularly endangered infrastructures, such as avoiding constructing roads in eroding places could also help to protect our habitats from the possible effects of climate change.

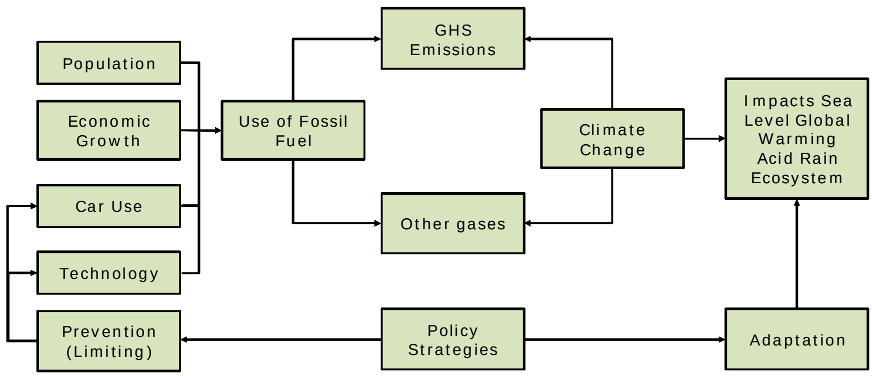

Figure 12. Overview of the global warming problem.

The gas primarily responsible for the greenhouse effect is believed to be carbon dioxide (CO_2). Global CO_2 levels are known to have increased since the industrial revolution. One reason for the increase is believed to be deforestation; there has been a decrease in the amount of vegetation which can absorb naturally or artificially generated CO_2. Another reason is the increased burning of fossil fuels. Figure 13 shows the role of the transportation sector as a source of carbon dioxide emissions from energy use.

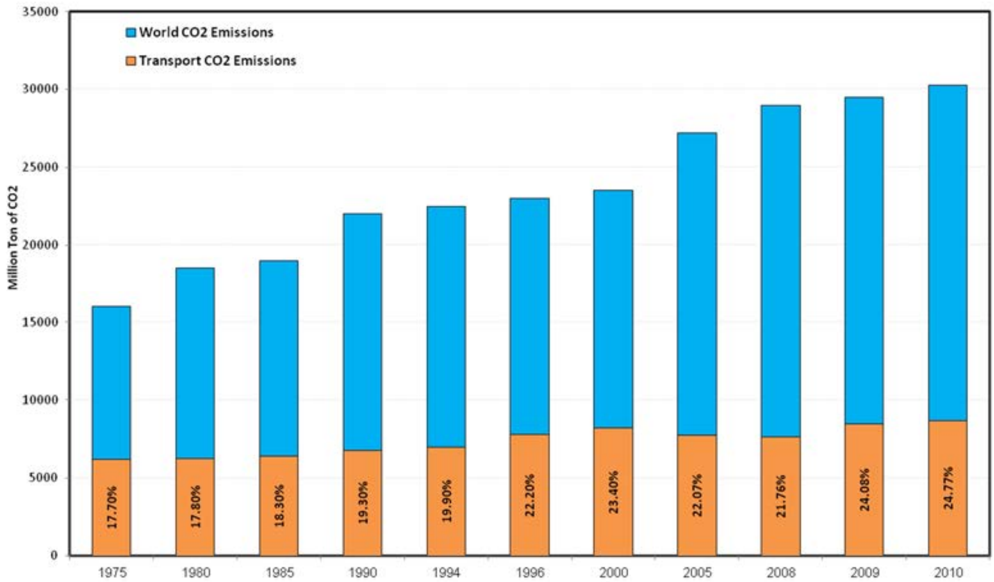

Figure 13. World CO_2 emissions total and transport sector (IEA 2012).

The other prevalent GHGs emitted from mobile sources are nitrous oxide (N_2O) and methane (CH_4). Some minor atmospheric constituents, such as the nitrogen oxides (NO_x) and carbon monoxide (CO), although not important GHGs in their own right, can influence the concentration of the GHGs through atmospheric chemistry.

If the fuels (mostly composed of hydrocarbons) are completely combusted, the only products emitted are CO_2 and water. However, under actual conditions, not all the fuel is combusted completely. As one example of combustion-related emissions, the vehicles release large portions of N_2O emissions. These emissions are closely related to air-fuel mixes and combustion temperatures.

CH_4 emissions from the vehicles are a function of the methane content of the fuel, the amount of hydrocarbons passing unburnt through the engine. The emissions of unburned CH_4 are lowest when the quantity of hydrogen, carbon and oxygen are present in exactly the right combination for complete combustion. Thus, CH_4 emissions will be determined by the air-fuel ratio. They are generally highest in low speed and engine idle conditions.

5.1.3 Sustainability

Figure 14 illustrates the multi-stepped process proposed to evaluate different policy techniques. Based on transport activities, expected vehicle stock and new technology trends, energy consumption and emissions (in the target year) can be calculated.

Then, different scenarios for reducing energy consumption are prepared and analysed. Each scenario may contain an abatement measure or a set of measures. The scenarios should be compared with each other as well as with the so-called "reference scenario". The reference scenario is defined as the solution that is based on the authorized transportation master plan, if available and/or "business as usual" travel behaviour. The scenarios are evaluated against sustainability targets. Target scans relate to reduction or improvement or they can be limits that cannot be undershot.

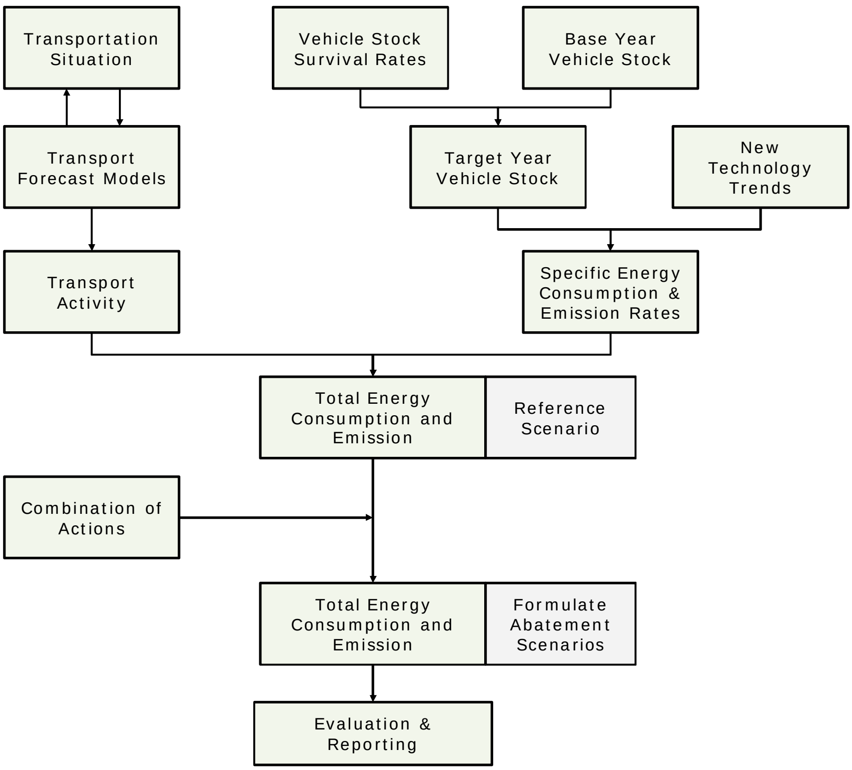

Figure 14. A multi-stepped process for the evaluation of policies techniques (Shahin 2001).

For the calculation of transport activities, travel demand models are needed. The models can also be applied in order to predict the effects of measures with modal shift and travel demand reduction objectives. It is very difficult to predict the effects of the measures with other objectives, such as fuel switching, energy saving, public education of vehicle drivers and vehicle maintenance. In this case, the effects of the measure can be estimated roughly by applying limited experiments or by investigating the results obtained from countries which have already carried out such measures.

In addition, it is important that the model should have an indication of the nature and magnitude of the effects of changes in the many factors that contribute to energy consumption models.

Some procedures should be developed in order to improve the data quality and to resolve uncertainties affecting emission estimates. This may involve the use of standard deviations, ranges of uncertainties, or some other means of indicating the reliability of the data. This issue must receive additional attention in any follow-up process.

Sustainable development of energy consumption and related emissions can only be achieved with the aid of drastic policies because:

- The spatial patterns of activities and economies tend to improvement in the quality of living and rises in personal income, which lead to an increase in private car ownership, a decrease in the use of public transport and decrease in car occupancy. Growth in urban activities and dispersion of the population, which lead to increases of mobility and more transportation policies, concerning congestion and accidents, which sometimes result in more energy consumption.
- The majority of transport energy consumption will come in the next few years from those countries that are currently developing rapidly or that have economies in transition (e.g. China).
- Policies which are aimed mainly at improving the efficiency of the energy chain, will probably not achieve the required reduction in energy consumption due to the rebound effect: an improvement in efficiency will lower the price of energy which will in turn encourage the use of energy and thus cancel out part of the efficiency gain. Auxiliary equipment, particularly air conditioning, also tends to reduce efficiency gains. Higher safety standards mean that vehicles are heavier and use more fuel.

To achieve sustainable development, at least two different sets of objects need to work together (Figure 15):

Push-Down the growth in energy demand through:

- Planning infrastructure in view of sustainability. For mobility to be sustainable, transport should be understood as a mechanism to maximize access and not as a mechanism just to move vehicles themselves.
- Reducing the use of private cars through switching to non-motorized transport modes, public transport and substitution of transport (telecommunications), together with behavioural change.
- Promoting mobility through increasing the role of pedestrian and bicycle transport.
- Implementing measures for area-wide intelligent traffic systems and traffic calming.

Push-Up the energy supply through:

- Switching to alternative fuels, including renewable energy, by providing a strong financial incentive.

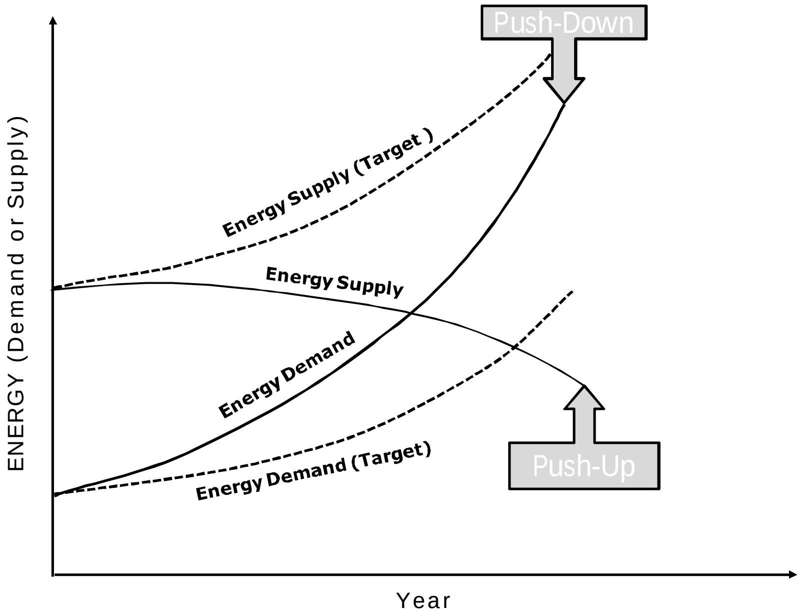

Figure 15. Towards sustainable energy consumption (push up & down approach).

5.2 Case example: New Borg El Arab City

Borg El Arab City (NBC) is one of the recently established cities in Egypt, created by presidential decree (506/1979). The total area of the city is 47 500 acres of which 26 700 acres are built up area. Its current population is 150 000 inhabitants; it is expected that the population will reach 570 000 inhabitants by 2022. Borg El Arab City is located 60 km west of Alexandria and 7 km from the Mediterranean coast.

This section includes results from the road inventory and surveys carried out by the team during March/April 2013. The following surveys were conducted:

- Road Network and Traffic Junctions Inventory
- Public Transport Inventory
- Railway Line and Station
- Borg El Arab International Airport.

NBC is today mostly an industrial city with most workers commuting from Alexandria. The city is connected with Alexandria through a number of main roads namely the Alexandria-Cairo Desert Road (Al Kafory Road) and the New Borg El

Arab City-Matrouh Road. In addition, NBC is connected with the national railway system through the Alexandria-Borg El Arab railway which can be employed in the future as an urban/suburban public mass transport system. Finally, NBC is connected with the International Airport through a single 2-lane road. The transportation systems connecting NBC with Alexandria are shown in Figure 16.

Figure 16. External road/rail network and site location of NBC.

5.2.1 Road network and classification system

In NBC, no clear road classification system was identified. Therefore, the team has suggested a road classification system based on the examination of the existing road and street network and their functions and physical conditions (or capacity) within the overall system. Accordingly, the classification of the existing road network in NBC could be described as follows:

- **Regional Roads:** these traverse the city boundaries and connect distant cities of the country. In NBC the King Mariout–Borg El Arab Road and the Marsa Matrouh–Borg El Arab Road fulfil the function of regional roads.
- **Collector Roads:** they are normally 3-lane or 2-lane dual carriageway with a large number of access roads. They provide links between regional roads. Mubarak Road, Ahmed Zewail Road, South Road, Western Road, North Road, Mohamed Najeb Road and Jamal Abd El-Nasser Road function as collector roads.
- **Secondary Roads (or Local Streets):** a secondary road network consists of a hierarchy of lower-order streets operating within the framework of a particular urban area. They could be divided or un-divided roads. Their function is chiefly to provide connections between collector roads, adjacent land uses, neighbourhoods and small-scale activity centres. Court Street and Ali Ibn Abi Taleb Street fall into this functional category.

5.2.2 Inventory of existing road network

In order to fully describe the road network in the project corridor, the team has collected a comprehensive data for the existing roads conditions (Appendix 2).

This was done through a site reconnaissance, a meeting with key stakeholders, Google Earth Satellite Images and revising the (available) previous studies. The road network could be classified into regional road, collector roads, secondary roads and local roads, as shown in Figure 17.

It is worth mentioning that the NBC road network does not have names for some road links. Based on the road inventory survey, the following items can be highlighted:

- There is no road hierarchy based on road capacities, importance or functions. This in turn would lead to traffic congestion, increasing traffic accident rates and reducing the efficiency of the road network as a whole.
- Incompatibility of certain intersections with safety provision and traffic operations.
- Lack of road signs and markings, particularly at approaches to intersections.
- Lack of proper organized pedestrian facilities, especially at street crossings.
- Lack of parking and insufficient drop-off provisions, particularly near main buildings. This would lead to illegal parking in the surrounding streets and usually cause traffic accidents.
- Insufficient, poor and unorganized public transport facilities and/or mass transit.

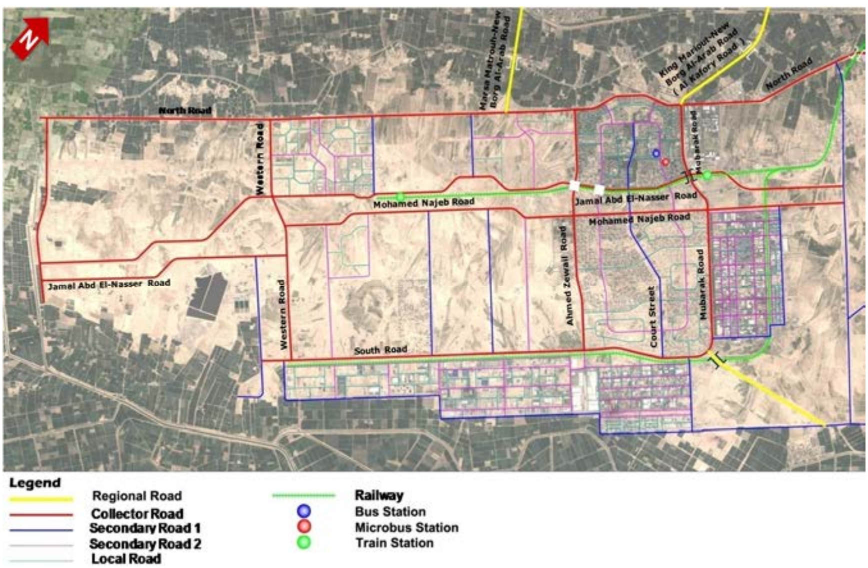

Figure 17. Road network classification.

5.2.3 Analysis of existing public transportation system

NBC faces a considerable lack of public transport services. Shortfalls in public transport have created market opportunities for the informal sector collective taxis and the ‘tuk-tuks’, small moped taxis, which have the advantage of changing their schedules and deviate from licensed routes in response to passenger demand and congestion, even though this might be illegal.

On the other hand, collective taxis and tuk-tuks create a number of transport problems that affect not only public transport but also adversely affect the entire transport system, such as:

- they are operated in an unorganized manner without a comprehensive view or plan,
- their network covers all road networks and in many precincts duplicates and competes with bus services,
- they often interrupt traffic by stopping suddenly or slowing at curbs to collect/drop passengers and have a low capacity compared to bigger busses or
- they are in poor technical condition, contributing significantly to air pollution and have high-energy consumption.

Figure 18 and Figure 19 show examples of the problems created by the informal public transport sector in NBC.

Figure 18. Illegal drop-off places for the informal public transport system.

Figure 19. Unorganized stations for the informal public transport system.

5.2.4 Analysis of existing pedestrian and bicycle transport

The ultimate goal of transportation is to provide access to goods, services and activities. In general, the more transportation options that are available, the better the access. Non-motorized modes are important transport choices, for trips made entirely by walking or cycling and to support public transport. In urban areas, walking and cycling are often the fastest and most efficient ways to make short trips. A built environment that is hostile to non-motorized transport reduces everybody's travel choices. A sustainable infrastructure is a healthy and safe environment. Optimally, pedestrian and bicycle transport is embodied and prioritized in the early design stages, taking into account optimal distances, safety and attractiveness.

NBC faces a considerable lack of pedestrian and bicycle infrastructure. The infrastructure does not prioritize space for bicycles and pedestrians. Specifically, the lack of indicated crossings increases the risk of accidents and leaves pedestrians feeling unsafe, thereby reducing these basic sustainable means of transport significantly.

Increased pedestrian traffic helps create a safer and more pleasant environment. Once visitors arrive in a community, they often explore it by walking and cycling. General examples of typical pedestrian and cycle routes and pedestrian crossing points are shown in Figure 20 and Figure 21.

Figure 20. Examples of typical pedestrian and cyclist routes (Bossi 2008, Ottawa 2011).

Figure 21. Typical pedestrian crossing points (Bonn 2007, Woodysee 2007).

5.2.5 Railway line and stations in NBC

The Alexandria–Borg El Arab line operates on the same track as the Alexandria–Mersa Matrouh line. The actual travel time between the Alexandria core area and NBC is around 1.5 hours. The vehicles operated on the line are inadequate to fulfil reasonable quality services, as they are outdated, poorly maintained, and have diesel engines with poor acceleration, deceleration and speed and poor seat quality, as shown in Figure 22.

Two stations exist on the NRC, namely 25 January station and Borg El Arab station. The two stations have recently been renewed, and are in good condition as shown in Figure 23.

Figure 22. NBC railway locomotive and passenger carriage.

Figure 23. Railway stations platforms in NBC: NBC station left, 25 January right.

The feeder systems (public buses and private operated mini-buses) to the railway stations to serve the passengers commuting to their actual destinations within the NBC are lacking, as shown in Figure 24.

Figure 24. Lack of public transport systems at NBC Railway Stations, NBC station left, 25 January right.

5.2.6 Borg el Arab International Airport

The Borg El Arab International Airport is located about 40 km southwest of Alexandria Centre and 14 km east of NBC. The airport consists of a new terminal building, administration and service buildings as well as cargo facilities. Currently the airport has one runway with a length of 3,400 metres and a width of 45 metres.

The airport is planned to become the main airport of Alexandria. The airport aims to serve passengers and cargo for Alexandria and the surrounding governorates. It will also help to develop and increase the export processes of these governorates, which have a huge number of industrial facilities and a lot of farmland. The airport will also help to improve the tourist development for the western region, especially Borg El Arab and the north coast.

The airport consists of a new passenger building and an administration building. The passenger terminal is designed in the shape of a boat and consists of three floors:

- Ground floor: allocated for check in and luggage handling.
- Second floor: allocated for arrivals, both domestic and international, in addition to administrative offices and airlines offices.
- Third floor: allocated for departures, both domestic and international, immigration procedures and a VIP hall. Commercial activities are spread among the three floors.
- Four movable boarding bridges connect the terminal building to aircraft.

The terminal contains a duty free shop, a franchise food court, an area dedicated for travel offices and other travel-related services, a fuel supply unit, a control tower and a fire station available to cover emergencies on site. Also, a parking area to the front of the building provides space for 350 vehicles.

The airport includes a new terminal with the capacity of 1,000 passengers per hour, and it is equipped with the latest equipment according to the instructions set by the organization of international aviation, to provide high-quality service to the passengers and airport security field as well, It also includes an air freight building with a capacity of around 10,000 tons per year, which can be increased according to the shipment requirements in this region.

5.2.7 Traffic surveys

A comprehensive traffic survey programme was undertaken in 2013 so as to establish the nature of existing traffic and travel characteristics across the study area. This information was required for the following reasons:

- To provide an understanding of current traffic levels and degrees of congestion at key locations across the study area, and
- To provide key traffic statistics across the road network which are specifically designed for building a Local Traffic Model for the study area.
- To evaluate the level of service (LOS) for the junctions concerned.

In order to evaluate the existing traffic conditions, the Team has conducted two types of traffic survey: Manual Classified Counts (MCC) and Turning Movement Counts (TMC). These surveys were conducted during the months of April 2013. Detailed results of the study can be found in Appendix 1.

5.2.8 Unsustainability of present transport system in NBC

The World Business Council for Sustainable Development defines sustainable mobility as “the ability to meet the needs of society to move freely, gain access, communicate, trade and establish relationships without sacrificing other essential human or ecological values today or in the future” (WBCSD 2001). The challenge is to discover ways of meeting mobility needs that are environmentally sound, socially equitable and economically viable.

The impact of modern development on the environment has long been a cause of concern at national and global levels. The rate and scale of the trends in environmental degradation, however, have been growing significantly with improvements in the standards of living.

Growing environmental awareness has led to the belief that infinite growth within a finite system is unsustainable and that the natural limits should be appreciated.

As a result of the expansion and development of the economy in general and the improvement of standard of living in particular, demand for transport of people and goods increases and, consequentially, energy consumption and pollutant emissions increase as well. Yet the increase in the quality of life, as a result of motorization, is starting to turn in the opposite direction; i.e. harming living standards.

The problems of a high level of motorization in NBC, inefficient use of scarce fossil fuel resources, emission of harmful pollutants and deterioration of quality of life are linked to such an extent that we can say there is a transport-energy-environment problem (Figure 25).

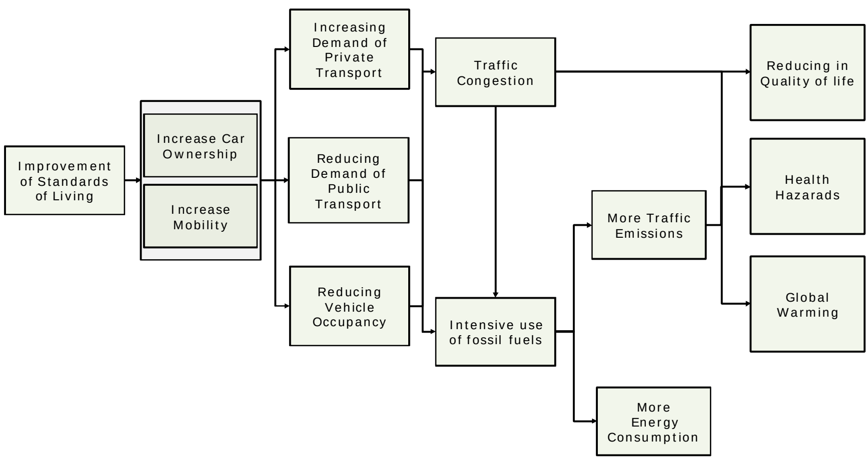

Figure 25. Transport-Energy-Environment problem in NBC (Shahin 2001).

6. Awareness-raising case examples

6.1 World Environmental Day (WED) celebration

WED aims to be the biggest and most widely celebrated global day for positive environmental action. WED activities take place all year round but climax on June 5. WED celebrations began in 1972, and have grown to become one of the main vehicles through which Egypt stimulates awareness of the environment and encourages political attention and action. Figure 26 shows a picture from one of these events, held in 2007.

Through WED, the people in charge of Environment in Egypt were able to personalize environmental issues and enable everyone to realize not only their responsibilities, but also their power to become agents for change in support of sustainable and equitable development.

Various issues that were highlighted through the past years during WED celebrations:

- WED 2012, Green Economy: Does it include you?
- WED 2011, Forests: Nature at your service
- WED 2010, Many species – One planet – One future
- WED 2009, Your planet needs you – Unite to Combat Climate Change
- WED 2008, Kick the Habitat Towards a low Carbon Economy
- WED 2007, Melting Ice – a Hot Topic?
- WED 2006, Deserts and Desertification: Don’t Desert Dry Lands
- WED 2005, Green Cities: Plan for the Planet.

Figure 26. Drawing competition in the Green Corner Library during World Environment Day.

6.2 Green Corner

The Green Corner is considered to be one of the most important programmes targeting environmental awareness among children and teenagers. With the prominence of Green Corner Libraries, the Ministry of State for Environmental Affairs adopted the Green Corner Project in 2001. The expansion and replication of the Green Corner has taken place in all Egyptian Governorates, and at the end of 2002 the establishment and refurbishment of 30 Green Corner sites have been developed in all Governorates. The Green Corner in Alexandria is located in the children's library – Elshalalat Garden, where the librarians are well trained to deal with Green Corner programme so as to promote environmental awareness among children and young people.

6.3 Alexandria University Environmental Forum

Alexandria University Environmental Forum started in 2006 to raise environmental awareness among all sectors of society, especially young people. Some of the forum topics were: environmental awareness essential to social development (2006), sustainable development between reality and aspirations (2007), environmental impacts of climate change (2008), and integrated management of solid waste (2012).

6.4 Egyptian Environmental Policy Programme (EEPP)

The programme extended from September 1999 to September 2002, and was funded by the U.S Agency for International Development (USAID). Technical assistance and training were provided for public awareness, and education for policy and awareness and policy dialogue, environmental sector analysis, information dissemination support. The Alexandria governorate joined the EEPP after March 2001.

6.5 Education Reform Programme (ERP)

The mandate of ERP was to assure quality education for all Egyptian children in schools that are themselves committed to continuous improvement through processes that the schools and communities control. Educational Development Centre (EDC) and World Education (WE) work to achieve this aim through a strategy of School-Based Reform. This was extended from June 2004 to June 2009. Target governorates of the programme were Alexandria, Cairo, Fayoum, Beni Suef, Minya, Qena and Aswan.

School-Based Reform (SBR) is a process rooted in recognizing the school as the agent for change through which quality education is achieved. A quality education is one that addresses the child's intellectual, social, psychological and physical development. The primary stakeholders whom an effective SBR approach must address were: teachers, school leaders and governance structures, communities and parents and the governmental systems which support the schools. Yet, while all of these stakeholders are important and have their roles to play in improving the quality of education and learning outcomes; the reform is driven from the base of the school.

The ERP approach to School-Based Reform was to empower school communities to direct their own change process. It was based on a partnership among the government, schools and civil society; and providing schools with the skills and knowledge they need to effectively implement the Egyptian standards to achieve accreditation for schools.

ERP supported schools and communities to make the changes needed to produce positive outcomes in the cognitive, social and behavioural skills of all learners.

By the end of the project, ERP impacted 308 schools, training 9,760 teachers on various environmental topics. The ERP formed the basis for the Environmental Education and Outreach Programme (E3OP) and made it easier to perform.

6.6 Environmental education & outreach program (E3OP)

The Egyptian Environmental Education and Outreach Program (E3OP) worked in collaboration with the Ministry of Education (MOE) and the Egyptian Environmental Affairs Agency (EEAA) to foster institutionalization of environmental education in Egypt. Funded by the United States Agency for International Development (USAID), the project was implemented by Education Development Centre, Inc. (EDC), with partners from the Academy for Educational Development (AED), Research Triangle Institute (RTI) and the Wadi Environmental Science Centre (WESC).

Over its two years of operation (August 2006 – September 2008), the project analysed existing environmental education materials and developed and disseminated new resources; provided teacher training to ensure a learner-centred, hands-on approach to environmental education inside and outside the classroom; promoted community participation in school community assessment, action planning and activities focused on environmental issues; and advocated environmental education as a pillar of quality education and sustainable development through partnership building and the media. By adopting a systems approach to development and serving as a catalyst, E3OP achieved a far wider and more rapid reach and greater potential for sustainability than is typical of projects of its scale. A broad-based, multi-stakeholder Egyptian movement in support of environmental education was initiated and gained significant momentum, and the ground has been well prepared for other, more substantial efforts to institutionalize environmental education in the Egyptian system.

It was very important, as environmental education increases public awareness and a knowledge of environmental and health issues and challenges. Through environmental education, people gain an understanding of how their individual actions affect the environment, acquire skills that they can use to weigh various sides of issues and become better equipped to make informed decisions. Environmental education also gives people a deeper understanding of the environment, inspiring them to take personal responsibility for its preservation and restoration.

There is now an advanced placement course for environmental science in Egyptian schools. Through a study (Gamal et. al 2006) aimed at measuring the extent of some environmental health knowledge among children in some preparatory schools, knowledge of environmental health was assessed in a sample of 400 students at four preparatory schools. The questionnaire sheet included information about the social status of families of students and school environment as perceived by students and some important essential environmental health knowledge. A sizeable proportion of students' families of language schools (100%) and of the governmental schools (over 75%) scored high, as did those of middle social status. The students critically assessed their schools, giving rates of poor standards ranging from 6–11%. The overall results of responses of students on the effect of presence of environmental pollutants on their health were poor, where 67–80% of students scored low. When relating knowledge of students to the social level of their families, it revealed a poor relationship. Recommendations were: theoretical subject matter in schools must be strengthened by practical training; parents association in schools should be provided by educational materials aids to help their reference information to their children and improvement of environmental education through children's TV programmes.

6.7 Women's Unit, Egyptian Environmental Affairs Agency (EEAA)

This unit contributes in raising women's environmental awareness through:

- spreading environmental awareness between woman's leaderships,
- assisting in forming new women's non-governmental organizations to share in environment protection projects in governorates,
- giving more attention to women in rural areas and activating their role in rural environment protection, and
- organizing training programmes and activities for girls in the environmental protection field.

Figure 27. An Environmental Seminar for Rural Women in Hares 2 Village, El Nahda area at Amreya, Alexandria in cooperation with Media Support Center in Alexandria about Environment Conservation, 2006.

6.8 El Mostakbal Association (NGO)

The El Mostakbal Association, located in Borg El Arab, was established in 1999 and has served the community through social activities. In 2009, it began a scientific training programme through its science club with school children in collaboration with Borg El Arab education management.

During 2009 some of the preparatory and secondary schools' female students; supervised by the Science Club, prepared a number of research projects about Dr. Farouk El Baz and the Development Axis Project and how to use the Groundwater to reconstruct the dessert.

During 2010 the children trained on preparing a simple water purification filter. In 2012 the association held a seminar on solid waste separation to increase its value.

6.9 Amal El Kher Association (NGO)

The Amal El Kher Association, located in New Borg El Arab City, is operated with younger members, provides socioeconomic support, activities and solves residents' problems such as poverty, illiteracy and disease through the following activities:

- Establishing small business for poor families to increase their income.
- Providing social support for poor families in order to overcome illness and poverty.

Organizational structure:

1. Upper Management: consists of 5 persons (3 young and 2 old experienced persons). They are responsible for organizing and managing the internal structure of the NGO and for approving members' decisions.
2. Youth Committees: they are carrying out the main activities of the NGO. Each committee consists of members and one leader assigned according to the experience and capabilities required. NGO committees are divided as follows:
    - Collecting Information Committee: their role is to collect required information about the city residents and their available sources of income.
    - Projects Committee: responsible for making feasibility studies for the projects that might be suitable for gaining income for poor families or any other NGO projects according with the Collecting Information Committee's results.
    - Communication Committee: responsible for linking all NGO Committees together and organizing the whole NGO's work flow.
    - Distribution Committee: allocating the NGO's services to poor families, such as food, medicines, clothes, etc.
    - Social Committee: developing a social network with the city residents and implementing social activities for them.
    - Women's Committee: concerned with activities in the city such as cooking, making accessories and knitting.
    - Children's Committee: explaining the purpose of charity for children under 12 years. Raising cooperation awareness among children and showing how their role can affect the whole community
    - Medical Committee: promoting health and medical awareness for poor families.
    - Education Committee: developing suitable training courses and other activities, such as seminars and summer camps, for the city residents.

6.10 Sonaa El Hayah (NGO)

Sonaa El Hayah is a charitable non-profit organization trusted by the city residents and all levels of society, seeking to enhance charity among young volunteers. The NGO vision is raising youth capabilities, upgrading their knowledge and combining their social activities for gaining tangible innovation for the whole society. The NGO mission includes the following points:

- encouraging Arab youth for charities work,
- establishing the concept of charity among young people by presenting examples of success,
- providing projects for poor families in cooperation with funding authorities, and
- developing suitable training courses and increasing positive spirit.

NGO projects include the following:

- Human: providing income-raising projects for slum residents; ensuring that all the family children complete their school learning phase.
- Future Protectors: running awareness campaigns about the dangers and hazards of drugs, especially aimed at teenagers.
- Our Health: providing free medical care to the poor.
- Upgrade your education: originally aimed at eliminating the illiteracy of one million individuals in 15 governorates by the end of 2013.
- Role Models: providing guidance for students at different stages in school to help conclude their curriculum and leading them to think and act positively.

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Appendix 1: Transport emissions in NBC

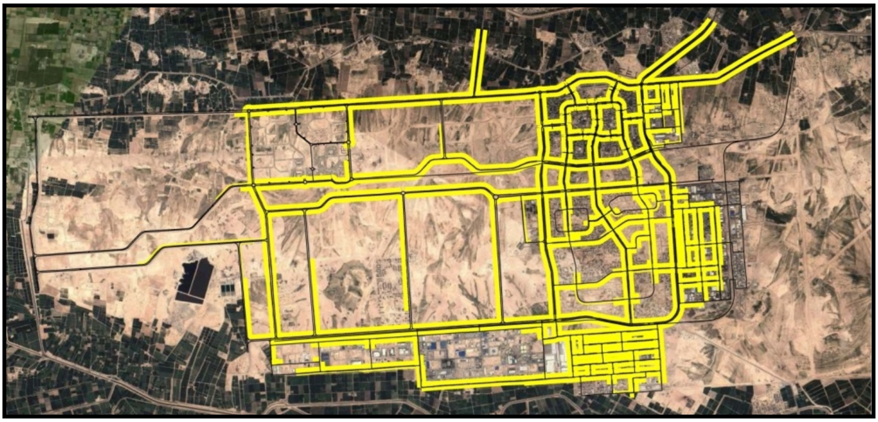

Figure 1/1. CO_2 emission within NBC during AM Peak Period.

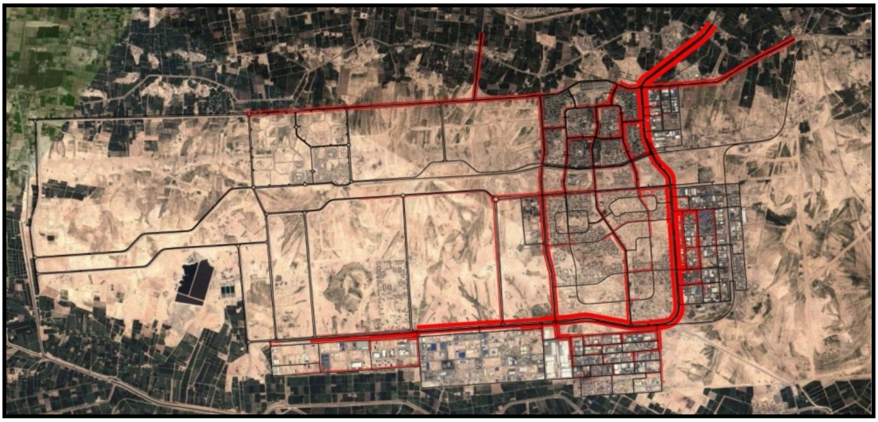

Figure 1/2. NO_x emission within NBC during AM Peak Period.

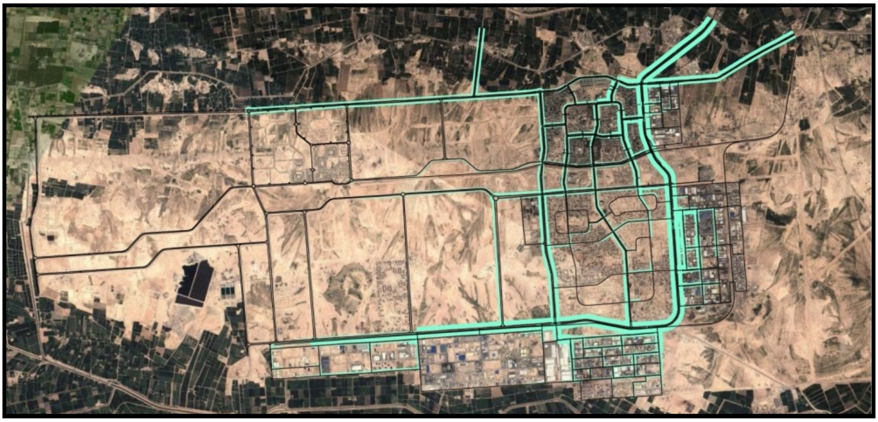

Figure 1/3. HC emission within NBC during AM Peak Period.

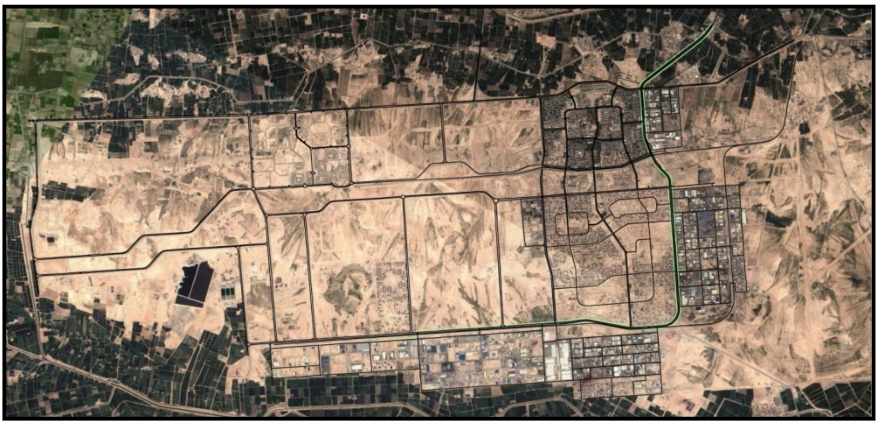

Figure 1/4. CO emission within NBC during AM Peak Period.

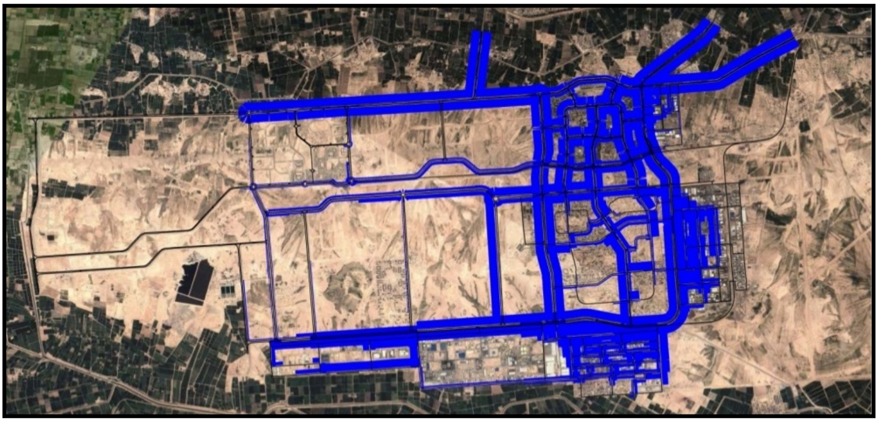

Figure 1/5. Fuel Consumption within NBC during AM Peak Period.

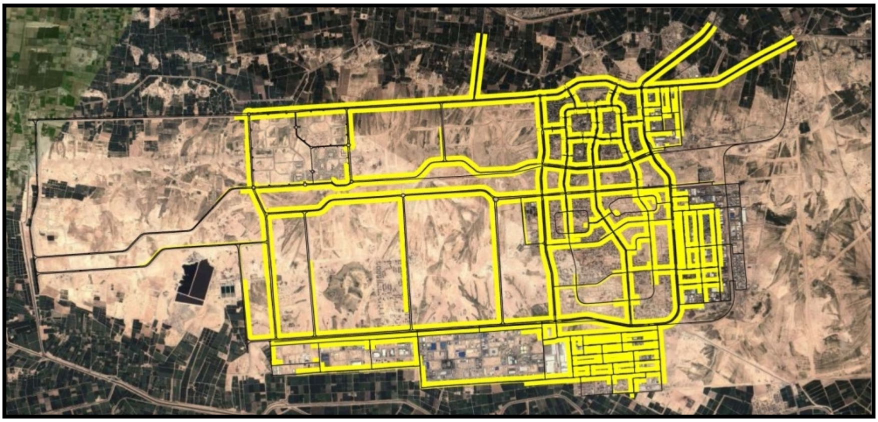

Figure 1/6. CO_2 emission within NBC during PM Peak Period.

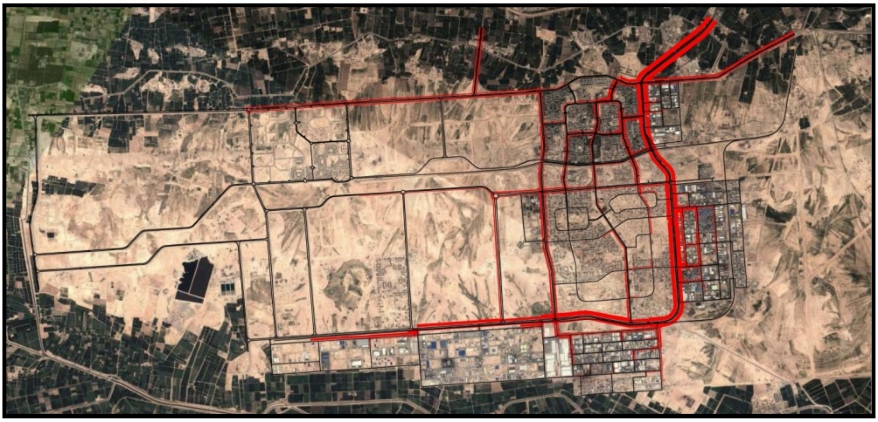

Figure 1/7. NO_x emission within NBC during PM Peak Period.

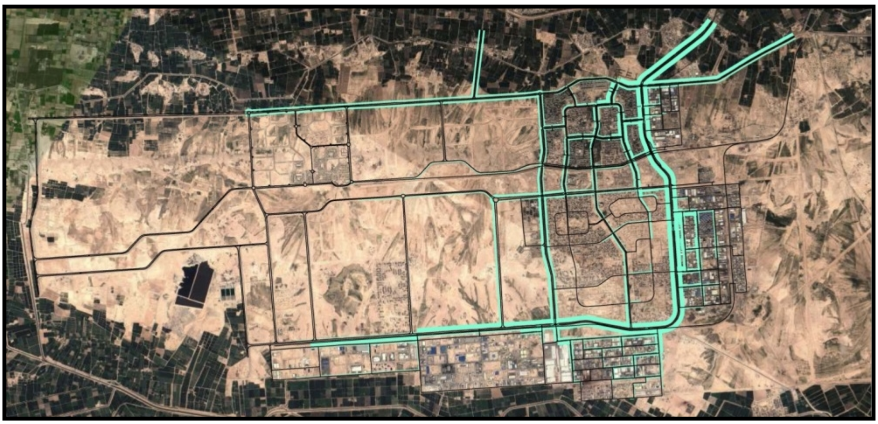

Figure 1/8. HC emission within NBC during PM Peak Period.

Figure 1/9. CO emission within NBC during AM Peak Period.

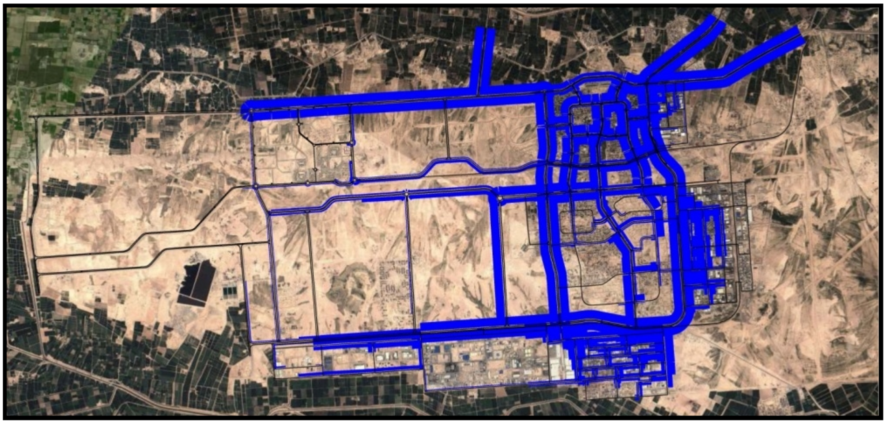

Figure 1/10. Fuel Consumption within NBC during PM Peak Period.

Appendix 2: Road network

1. Alexandria-Cairo Desert Road (Al Kafory Road)

Alexandria-Cairo Desert Road (Al Kafory Road) is 3-lane divided carriage way with three traffic lanes in each direction and is classified as a major regional road. The total width of the Road is about 35 meters. The following characteristics are depicted for this road:

- Road width varies between 11 ~ 12 meters in each direction with a median width between 14 ~ 16 meters.
- Good pavement condition.

2. Marsa Matrouh-New burg Al Arab City Road

Marsa Matrouh-New burg Al Arab City Road is 2-lane divided carriage way with two traffic lanes in each direction and is classified as regional road. The total width of the road is about 20 meters. The following characteristics are depicted for this road:

- Road width varies between 7 ~ 8 meters in each direction with a median width of 5 meters.
- Good pavement condition.

3. Mubarak Road

Mubarak Road is 3-lane divided carriage way with three traffic lanes in each direction and is located on the eastern side of the city and is classified as a collector road. The totl width of the road is about 37 meters. The following characteristics are depicted for this road:

- Street width is 12 meters per direction with a median width between 13 ~ 15 meters.
- Pavement Condition is good.

4. Ahmed Zewail Road

Ahmed Zewail road is 3-lane divided carriage way with three traffic lanes in each direction and is classified as a collector road. The total width of the road is about 35 meters. The following characteristics are depicted for this road:

- Street width is 12 meters per direction with a median width between 17 ~ 18 meters.
- Pavement Condition is good.

5. South Road

South road is 3-lane divided carriage way with three traffic lanes in each direction and is classified as a collector road. The total width of the road is about 35 meters. The following characteristics are depicted for this road:

- Street width is 12 meters per direction with a median width between 17 ~ 18 meters.
- Pavement Condition is good.

6. Western Road

Western road is 3-lane divided carriage way with three traffic lanes in each direction and is classified as a collector road. The total width of the road is about 40 meters. The following characteristics are depicted for this road:

- Street width is 12 meters per direction with a median width between 15 ~ 16 meters.
- Pavement Condition is bad.

7. Jamal Abd El-Nasser Road

Jamal Abd El-Naser road is 2-lane divided carriage way with two traffic lanes in each direction and is classified as a collector road. The total width of the road is about 30 meters. The following characteristics are depicted for this road:

- Street width is 7 meters per direction with a median width between 15 ~ 16 meters.
- Pavement Condition is good.

8. North Road

North road is 2-lane divided carriage way with two traffic lanes in each direction and is classified as a collector road. The total width of the road is about 22 meters. The following characteristics are depicted for this road:

- Street width is 7 meters per direction with a median width between 7 ~ 8 meters.
- Pavement Condition is good.

9. Mohamed Najeb Road

Mohamed Najeb road is 3-lane divided carriage way with two traffic lanes in each direction and is classified as a collector road. The total width of the road is about 40 meters. The following characteristics are depicted for this road:

- Street width is 12 meters per direction with a median width between 17 ~ 18 meters.
- Pavement Condition is good.

10. Court Street

Court street road is 2-lane divided carriage way with two traffic lanes in each direction and is classified as a secondary road. The total width of the road is about 25 meters. The following characteristics are depicted for this road:

- Street width is 8 meters per direction with a narrow median width between 6 ~ 8 meters.
- Pavement Condition is good.

11. Ali Ibn Abi Taleb Street

Ali Ibn Abi Taleb road is 2-lane divided carriage way with two traffic lanes in each direction and is classified as a collector road. The total width of the road is about 30 meters. The following characteristics are depicted for this road:

- Street width is 7 meters per direction with a median width between 5 ~ 8 meters.
- Pavement Condition is good.
- Allowed On-street parking.

12. Junctions

The NBC road Junctions suffer from the following:

- Inappropriate control type at main intersections;
- Lack of appropriate traffic signing and marking at most intersections;
- Lack of appropriate visibility especially from the secondary road approach at some locations;
- Lack of traffic islands (neither road marking nor by curbs) within the intersection effective area;
- Some movements, usually left turns, are allowed wrongly at some locations resulting in an insecure intersection;
- Lack of Speed-Changing Lanes (acceleration and deceleration lanes) or Transition Wedges at main intersections.

Figures 2/1 to 2/4 show examples of the problematic junctions as an example for the above mentioned deficiencies**.**

Figure 2/1. King Mariout-New Borg Al-Arab Road (Al Kafory Road) and Mubarak Road Junction.

Figure 2/2. Court Street and Railway Line Junction.

Figure 2/3. Court Street and Jamal Abd El-Naser Road Junction.

Figure 2/4. Ahmed Zewail Road and South Road Junction.

Series title and number
VTT Technology 161

Title	**Readiness for EcoCities in Egypt** **Insights into the current state of EcoCity systems, technologies and concepts**
Author(s)	Åsa Hedman, Carmen Antuña Rozado, Ola Balbaa, Yehia ElMahgary, Ali El-Nashar, Ahmed ElShazly, Mona GamalEldin, Ahmad Hamza, Jutta Jantunen, Ali Kamel, Abdelazim Negm, Heba Saeed, Boshra Salem, Mohamed Shahin, Ahmed Tawfik, Pekka Tuominen, Walaa Youssef & Ahmed Yousry
Abstract	The objective of this report is to provide a general overview of the current state of urban planning, energy systems, water and waste management, transportation planning and raising general awareness. One objective is also to provide some general information about what the EcoCity concept means in the Egyptian context. Some case examples are given in order to give an idea of the practical conditions on the ground. An EcoCity essentially has high ecological quality, but at the same time it is technologically sophisticated and modern. The attempts to build an EcoCity so far have been based on optimization of different sectors or technologies, and thus they are a compromise between the high-level targets and the present level of design. However, there is not just one EcoCity concept but a variety of possibilities that need to be adjusted to fit the local context, local culture and local economic realities. This is the way to achieve a possible solution with regard to the local resources, but at the same time to meet the high goals set for an EcoCity. High-tech solutions are one way to the EcoCity, but they are not the only goal of an EcoCity. The main elements of an EcoCity are a dense city structure, clean energy production, minimal energy consumption, sustainable transport solutions, ecological water and waste solutions and the inclusion of social aspects. In Egypt the biggest challenges in terms of EcoCities concern transportation. Bigger cities have big problems with too many private cars and the lack of functioning public transportation systems. Water resources are scarce in Egypt, and they have therefore to be given special focus when planning sustainable city structures. There is a high level of know-how about water handling systems. The main challenges are in finding investments for the solutions. As regards energy, there is a major saving potential in terms of electricity usage. Regarding renewable sources, the biggest potential is in solar energy. To achieve sustainable cities, focus must also be put on awareness-raising activities and on developing governance structure
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