International Journal of Sustainable Development and Planning
Vol. 17, No. 3, June, 2022, pp. 795-811
Journal homepage: http://iieta.org/journals/ijsdp

Towards Resilience: Energy Efficiency in Urban Communities - Case study of New Borg El Arab City in Alexandria, Egypt

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https://doi.org/10.18280/ijsdp.170310

Received: 8 February 2022
Accepted: 22 April 2022

Keywords:
built environment, energy efficiency, New Borg El Arab city, resilience, urban planning framework

ABSTRACT

Energy demands is one of the most important challenges for the future of urban communities and its built environment. Hence, the resilience of energy in urban communities is one of the effective concepts used to face the energy crisis fact due to the intensive consumption of energy. In this context, the paper is concerned with reviewing the previous literature for urban energy. resilience principles and energy-built environment frameworks by specialized international organizations and also studying the experiences of two top ranked international resilient cities. This paper proposes an energy resilient built environment conceptual framework in order to better recognize and examine the complicated problems of resilient and energy efficient urban communities. An analytical approach was applied for the current situation of New Borg El Arab City in Alexandria, Egypt using the proposed framework for measuring the resiliency level in the built environment, then applying an AHP method for determining the priorities of its built environment components, which need to be developed in order to achieve a resilient city. Thus, the overall goal is to provide a model to city planners and decision-makers that could enable them to plan for adaptable urban communities to be more resilient towards energy vulnerability.

1. INTRODUCTION

Urban communities vary widely in shape, scale and function, reflecting diverse cultures, histories, topographies, economies and technologies. They are considered as a broad system with various interconnected components, which are economic, social, environmental and built environment and they require intricate planning to drive development toward desired goals [1]. Therefore, urban planning is best thought of as a process used to achieve envisioned and desired goals within the natural and built environments to enhance the quality of life. Resilience is a new concept, which profoundly touches and presents an involved and multidimensional challenge to urban planning.

"Building resilience is an expanding theme in today's world. Now more than ever, the ability to cope with and adapt to challenging and changing circumstances and emerge stronger than before is essential in helping cities navigate uncertainties" [2]. The resilience concept is a sustainability's prespective, as a strategy is dynamic, involved, nonlinear and based on the awareness of city systems for handling and responding to urban vulnerability, stresses and shocks [3]. It is the capacity and capability of a system or community facing vulnerabilities to respond and cope with changes and disturbance or stresses and to continue its function, recovery and reorganize while undergoing change without changing its basic state to return to its equilibrium within the urban context [4, 5].

The resilience in urban communities depends on its built environment, social, ecological, environmental, economical, infrastructural and governance components [5, 6]. Therefore, this concept builds upon the urban perspective as complex responsive systems in reacting to urban weaknesses, such as the energy crisis. Additionally, some principles are identified from this concept to tackle vulnerabilities quickly and respond actively to risks for building resilience in urban systems [7, 8]. Energy needs represent among the greatest challenges facing the cities' future and its built environment; hence, urban energy consumption an issue of critical research in the past 35 years and is foreseen to remain an important challenge in the succeeding years [9]. Furthermore, in recent studies, energy researches have almost been neglected in the urban planning strategies and unfortunately, there still exists a gap regarding the definition of the resilience of energy in the built environment and how to integrate resilience principles and urban energy criteria in the built environment [10-12]. Thus, the phenomenon of energy crisis is today recognized as one of the most urgent problems facing humankind that makes it a hot spot to shift to a pattern with high energy resiliency [13-15].

Egypt, as one of the MENA region countries, faces significant challenges in its energy sector, more so in its built environment which have a higher energy consumption. Thus, the built environment needs to deal with such vulnerability and to be able to respond effectively to maintain its energy resiliency. Therefore, a conceptual framework for energy resilient built environment is needed to integrate the urban resilience to the built environment components in order to achieve resilient city toward energy vulnerability.

The built environment promotes a sense of community by encouraging daily engagement with people, nature and other environments. It touches all aspects of life through its main components and subcomponents which should be taken into consideration to achieve the energy resilience in built environment. In addition, the built environment is considered as a significant component of every urban community that is the primary habitat for the increase of population, the use of urban nature and resources, and the transformation of the physical environment. when moving towards the concept of sustainability and resilience, it plays an important functional and operational role at a time of risks and vulnerabilities to increase the capacity of built assets and provide protection to people and cities. With the resilient thinking, urban communities need to be adaptable in the sense that they need to explore the challenges involved in the built environment, able to withstand and adjust to vulnerabilities and have the possibility to grasp and transform into a state that survives future change [16].

The paper proposed a framework which summarizes the relationships between the built environment components and subcomponents respecting the urban resilience principles to evaluate the energy system in the built environment.

The methodology of the research presented in Figure 1 includes two main parts. The first part is a literature review that presents the urban resilience concept and principles and analyzes many energy efficiency frameworks in urban planning as well as investigating two cities, which are classified internationally top ranking in resilience as Stockholm and Paris were selected while a personal experience of the researcher from her repeated visits to and the availability of realistic survey and photographs of both cities. The second part is an application of proposed framework on the selected case study of New Borg El Arab city in Alexandria, Egypt to analyze its built environment for energy vulnerability and evaluate the energy resilience, then applying the Analytic Hierarchy Process (AHP) method, which is an approach based on pairwise comparisons at different hierarchical levels with a scale from 1 to 9 for measuring the relative significance of features to rank them [17], to identify the priorities of its built environment's components to upgrade the resilience level of energy in the city.

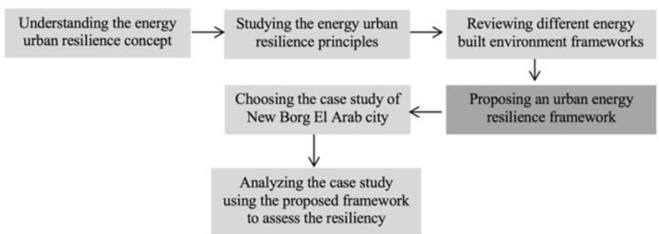

Figure 1. The methodology adopted in the research

2. URBAN RESILIENCE

Resilience is frequently used in various approaches, although urban resilience is a relatively new concept as it attracted attentiveness in urban planning and city development in the last few years and is still hotly debated [18-20].

Urban resilience can be described as the urban systems' capacity to resist risks and stresses, cope changes, survive shocks, use them, rearrange, develop while preserving their duties, and maintaining the same fundamental features and character [21-23]. According to UNISDR, urban resilience means the ability of a system or community exposed to hazards to absorb, withstand, cope with and retrieve from danger impacts rapidly and efficiently, comprising by restoring and preserving its fundamental features and structures [5].

Urban resilience should be created upon the approaches of the environment, ecology, society and economics and the dynamics of a specific location, and it needs to be incorporated into a series of related scales [24]. Moreover, it is linked to preparations for minimizing disruptions and activities to address them when they occur, and it is a continuous time-scale process to reshape, reorganize and develop new adaptation plans [18].

2.1 Urban resilience dimensions

The urban ecosystem has its limitations to solve vulnerabilities, instigating a need for a more comprehensive system and concept. Thus, there was an urgent need to find a concept that can be used in urban communities to solve their uncertainties.

To understand the urban resilient model to bridge the gap between the urban systems and the shocks that threats the urban communities, many organisations and researchers have reviewed the urban resilience dimensions through various perspectives. Two popular urban resilience dimensions' models are summarised as follows:

Rockefeller's City Resilience Foundation organized a model, as shown in Figure 2, to help urban communities to strengthen resiliency, identify their weakness, resist shocks and stresses, improve its resilience and shape urban planning, practice and investment, according to four essential dimensions that are the following [25]: The health and well-being, economy and society, infrastructure and ecosystems, and leadership and strategy. Every dimension comprises indicators that indicate the urban activities that may use for enhancing their resiliency. This model underlies many aspects of the urban resilience that can be studied in depth, respects the ecosystem resilience's field and promotes new forms of analysis for understanding the urban complexity.

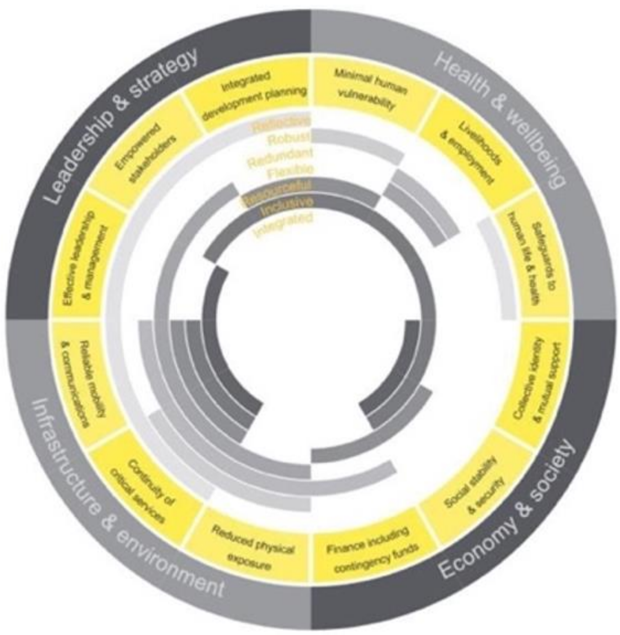

Figure 2. Rockefeller's city resilience framework [25]

Resilience Alliance Initiative was established to provide a scientific basis for formulating positive strategies of the urban future within the urban resiliency context, the urban resilience is outlined by four main dimensions, as shown in Figure 3, which are metabolic flows focusing on flows of materials and energy within cities and interactions between supply, production and consumption; social dynamics emphasizing inequalities, changes in population and human capital; governance networks concentrating on changes in institutional systems and urban decision makers ;and built environment highlighting on urban features like landscape, city's spatial organization, infrastructure, services, roads and green areas [26].

The Resilience Alliance integrates between the dimension of metabolic flows covering energy resources as urban systems and the dimension of built environment covering urban features which is the principal scope of this paper to achieve urban resilience and support cities responding to vulnerabilities.

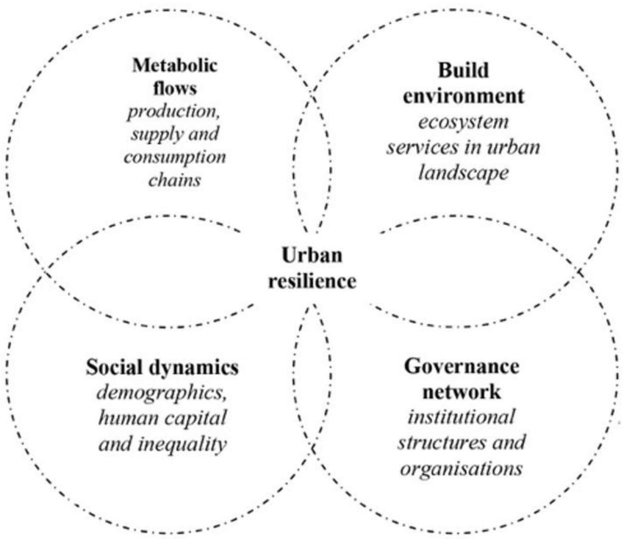

Figure 3. Four interconnected urban resilience dimensions [26]

2.2 Urban energy resilience concept

Urban Resilience is a more strategic concept that can help to integrate ecology and urban planning design and improve the cities and its built environment. In addition, the ecosystem is dynamic and opens to the flow of input and output resources such as energy from the system as a whole [24, 27]. Urban community as an ecosystem can be seen as a giant organism, which consumes materials and energy from the environment and its metabolism must be organized to allow energy flows in order to minimize vulnerabilities in the built environment in terms of resilience [28].

Energy is considered a valuable resource of satisfying everyday human requirements and activities that can't be reached with no energy therefore the availability of a huge amount of energy is required. The energy crisis has become recognized as one of humanity's most urgent problems, that marks a hot spot to move to an energy resilient model. The significance of energy resilience for the actual existence of urban communities, is a concept that has not yet been studied in depth and deserves further study [29]. Over the past few years, thinking about resilience has been utilized more and more to understand how urban areas and its built environment function to face vulnerabilities and provides a natural resource management method such as energy, which encompasses both natural and human systems [29, 30]. As energy is the material basis for urban development, the planning of energy resilience in the built environment represents an effective tool to fight against the energy crisis in any urban areas due to energy intensive use in the built environment [10].

Urban energy resiliency concept covers urban development's aspects whether natural or constructed to the well-being of residents also economic and social matters, supported by efficient governance [31]. It consists of ensuring that an urban community has a regular and reliable supply of energy and emergency system response in case of a power failure.

2.3 Urban energy resilience principles

Energy flows in the built environment across land use, transportation and infrastructure are largely unexplored; thus, there is a need for promoting high built environment resilient systems capable of facing energy vulnerability with greater flexibility [32]. In order to incorporate the energy system and the resilience concept some principles have to be identified to facilitate the integration to achieve a resilient built environment for energy vulnerability. Principles for urban resilience are significant in preventing systems breakdown, enabling applicable and suitable actions, and moving toward a more resilient city, which basically is sustainable, livable, safe, or wealthy. The following principles are as general principles that are not mutually exclusive and often overlap, any resilient system should possess. These principles are from extensive researches, oganisations and reports [2, 25, 27, 29, 33-35] and shed more light on the resiliency in urban context with a focus on energy system in the built environment and needed to achieve resilience within the urban energy system:

2.3.1 Robustness

It is the strength of a well-conceived, constructed, and managed system to resist attack and be able to withstand and absorb the short-term disturbance, severe external and internal shocks with no significant damage or systems' function loss. Robust design provides for foreseeable risk and helps urban communities to produce the energy requirements at the site and with an energy-efficient built environment.

2.3.2 Resourcefulness

It refers to the adequacy and stock of available and alternate resources at any time to policy makers and planners for a proper understanding of the current conditions, identifying weaknesses, responding, recovering and preparing for possible disturbances. It creates layers of communities; promoting collaboration and communication between citizens, that benefit local economies.

2.3.3 Efficiency

It signifies the energy resources amount supplied by an urban system for the input of the energy resource, it has to increase the productivity of resource uses and decrease wastes. In addition, the reduction of demand for energy resources is significant to conserve energy and improve the efficiency of the urban systems.

2.3.4 Diversity

It relates to the mixed use and activities in urban systems that offer a variety of options and safeguard the system from diverse pressures. It increases the urban systems as a living place and the homogeneity of built forms, which produce attractive urban features.

2.3.5 Flexibility

It concerns the capability of a system to safely sustain failure also the capacity and readiness to adapt other approaches responding to evolving circumstances. For the maintenance of urban system performance in case of disasters, should be able of predicting risks to resist the breakdown and making certain modifications to the subsystems in order to ensure a safe and survivable urban system.

2.3.6 Mobility

It encourages walking and social interacting throughout continuous linkages among neighborhoods. This action can be achieved by using a dense grid of roads, delivering all conveniences for daily requirements and suitable walkable distance is greatly considered, and redesigning the streetscape, providing greater transportation options and including more green space to increase accessibility and safety.

2.3.7 Creativity

It is the strength of a well-conceived, constructed, and managed system to resist attack and be able to withstand and absorb the short-term disturbance, severe external and internal shocks with no significant damage or systems' function loss. Robust design provides for risks and helps urban communities to produce the energy requirements at the site and with an energy-efficient built environment.

2.3.8 Equity

It is critical to achieving resilience through the equitable allocation of resources within the community related to exposure to effects for producing and distributing resource. It is essential to shaping resilient urban areas by encompassing social issues as well as improving public participation in decision-making and environmental fairness to provide a more resilient city and lead to social equality in urban center.

2.3.9 Identity

It is essential to enhance the identity of a city, develop a greater sense of place, preserve its natural assets, landscapes and cultural heritage together within rich and ever-evolving art and cultural offerings. It contributes residents to be thrive and enjoy attractive places where they feel identified, accepted, and safe.

3. DIFFERENT ENERGY BUILT ENVIRONMENT FRAMEWORKS

Energy is important in the built environment to enhance the quality and comfort of urban life. Therefore, it is necessary to incorporate energy system as a major consideration in the built environment to develop a systematic analytical and design system that would become a part of every stage of the development process. Population growth and the supply of new dwellings are increasing energy demand, thus the energy consumption reduction, the efficient use of energy resources and the integration of renewable energy should be considered within the built environment [36, 37]. In the context of urban planning, the urban planner and designer are beginning to explore principles and ways to integrate energy in new and existing built environment. Recently, for reducing the energy consumption and aiding energy savings within the built environment, the energy efficient principle is implemented by organizations, urban experts and researchers [38, 39]. But there is an urgent need to study the energy system more comprehensively than efficiency by implementing the comprehensive concept of energy resilience instead of depending only on the efficiency principle representing one of the resilient built environment principles. Thus, the following represents certain energy-built environment frameworks proposed by organizations, researchers and urban planners:

3.1 MED-ENEC energy efficiency for MENA urban planning framework

The training workshop on energy-efficient city planning was hosted by the housing research center's urban training institute, led by the ministry of housing utilities & urban communities held with MED-ENEC partners in Egypt focused on energy efficiency in urban planning and proposed some guidelines, in Figure 4, to achieve an energy efficient framework in the Egyptian planning context. These guidelines are created by analysing international environmental sustainability best practices, and conventional approaches which were utilized in the neighborhood planning to create comfortable climates to reach the energy efficiency in the built environment and allow flexibility in design and planning according to site-specific conditions [40].

3.2 UNHABITAT energy and resource efficient of urban neighborhood design framework

UNHABITAT developed an environmentally and energy-friendly framework for the design of energy and recourse efficient urban neighborhoods in Figure 5. There are performance requirements in the built environment needed for the planning and design of new districts and they are primarily as follows: welfare; energy efficiency and clean energy resources; and environment quality and sustainability [41]. The framework gave an appropriate comply with those needs as UNHABITAT summarized some interconnections that happen between the built environment and other features of planning.

3.3 World bank & ESMAP energy efficient and livable cities framework

The World Bank group and the energy sector management assistance program presented the following framework that demonstrates energy-efficient and liveable urban planning and suggests there is a close relationship between the habitability of cities and their level of energy consumption with their built environment components and subcomponents. This framework, as shown in Figure 6, emphasizes that the planning of cities and its built environment has been reshaped with important energy-related consequences in addition to cities' resiliency and quality of life [42].

Urban structure	Urban morphology	Buildings	Renewable energy	Context
Layout, Zoning Density, Mobility Accessibility	Massing Parcellation Outdoor spaces	Building types Architectural elements	Flexibility integration	Topography Climate Framework

Figure 4. MED-ENEC urban planning framework

Open spaces	Mobility	Buildings	Energy	Water	Solid Waste
Urban design	Transport Accessibility	Architectural design	Consumption Production Efficiency	Use Cycle treatment	Recycle reuse

Figure 5. UNHABITAT framework

Built up areas	Land use	Transportation	Buildings	Infrastructure	Bioclimatic design	Social services
Urban pattern Compact masses	Mixed use Density parks	Pedestrian network	Form Material Environmental treatment	Road Street network	Green areas Climatic conditions	Facilities Amenities

Figure 6. World Bank & ESMAP framework

Land management	Transportation	Buildings	Energy	Water	Electricity	Agriculture	Waste
Blue & green infrastructure construction, urban forest conservation, wetland restoration /construction	Non-motorized strips and public transit infrastructure construction, green clean transport, development access to mobility	Construct-ion green roofs installatio n, climate-adaptive architectur e Green principles/ measures	Develop-ment/use of renewable energies (biomass, solar, wind) Thermal (Solar Water Heating) Waste to Energy (Agriculture /Biogas)	Rainwater harvesting wastewater cycling	Street lighting water pumping	Crop switching rotation, erosion control minimum tillage, aquaculture diversifica-tion	Reduce/ minimize, re-use, recycle, environmen tally sound disposal Waste Managem-ent

Figure 7. UNEP agenda

3.4 UNEP resilience and resource efficiency in cities agenda

UNEP concluded that efficient use of resources and energy are fundamental components for city resiliency, and may be achieved more efficiently when constructed within the context of a resilient system. This organization demonstrates series of actions which may be assumed as meeting the requirements of resiliency, resources and energy efficiency. The actions 'areas that strengthen resiliency and efficiency of resource agenda are: individuals, institutions and governance networks, infrastructures and services, metabolic flows and natural ecosystems. These activities support cities to increase resource efficiency through greater flexibility and better ability to deal with changing conditions. This agenda, as shown in Figure 7, provides opportunities for more efficient resources and increases the city resiliency by decreasing the risk's exposure for insufficient critical inputs and relying more lightly on resource supply systems [43].

4. EXAMPLES OF RESILIENT URBAN COMMUNITIES

Two top ranked international resilient cities were selected to analyse their development, one is an existing city and the other city is a new city to study different circumstances. A big contrast is seen in these two cities to achieve resilience. The main vision of the existing city is transforming to resilient city by solving the current problems such as pollution, traffic congestion, high population terrorist menace and the issues of health, food and water. However, the vision of the new city is creating a resilient city by well exploiting the resources and technology such as using energy efficiency design and materials in buildings and open spaces. The analysis of both cities focuses on their applied principles which strives to weave the principles of energy resilience into criteria of urban design.

4.1 Stockholm

The city of Stockholm, the capital of Sweden, started to build an ecologically sustainable city district around the Hammarby Sjo in 1996. This lake gave its name to the city's new district surrounding it. Hammarby Sjostad, as shown in Figure 8, is a neighborhood situated in the south-central inner city of Stockholm, close to the city center, which was previously a contaminated industrial site and old port area which was developed and planned to be a sustainable district community with new environmental solutions. Hammarby Stostad's objective is to create a resilient urban neighborhood that could be double as effective in reducing the impact on the environment, and consume half of the energy utilized during the usual expansion [44].

Figure 8. Hammarby

A Glashusett environment information center building, in Figure 9, offers talks about sustainable urban planning and inspires the residents to modify their lifestyles for greater sustainability. More than 10,000 policymakers and experts visit this center each year, which makes this place one of the major international site visits in Stockholm [45].

4.1.1 Hammarby Sjostad model

Stockholm has developed a Hammarby model, in Figure 10, which is has reduced the overall impact on the environment and become a role model for world-wide sustainable and resilient urban planning projects. Large ambitions for resilience development have been embedded in planning processes and new innovative environmental solutions for water, energy and waste management have been considered at architectural and infrastructural level. The neighbourhood planning is the result of a positive collaboration between city authorities, urban planners, developers, architects, landscape architects, engineers from eco-technology companies, water agency and Fortium energy enterprises. This project provided a model of resilient urban planning and eco-friendly neighborhood and transformed Hammarby Sjostad into efficient evidence which ecology and urbanism work jointly through means of comprehensive planning [46].

Figure 9. Glashusett building and Hammarby model displayed in Glashusett center

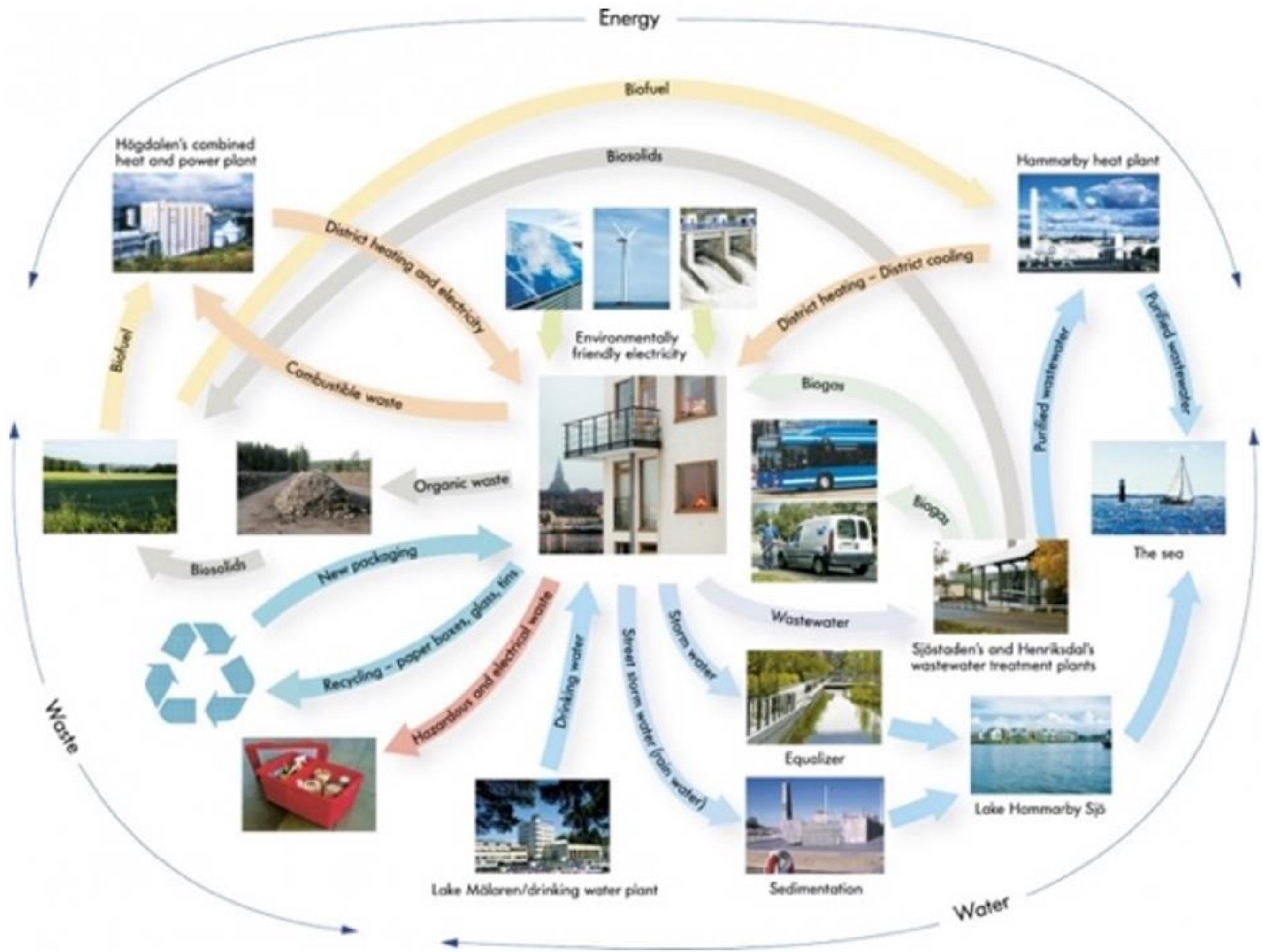

Figure 10. Hammarby Sjostad model [47]

The design of Hammarby Sjöstad complies with Stockholm city center standards and brings additional city growth in Stockholm a modern city based on semi-open blocks, combined traditional types of urbanism are inspired by Stockholm's city centre through modern architecture and inclusive forms of planning [47].

The development has necessitated gradual elimination of former industrial and terminal zones, existence of density on an urban scale with a focus on preserving current ecosystems and implementing progressist policies on building and housing the dimensions of the streets of the city center, the size of the blocks, the height of the buildings, the functionality and density assembly are incorporated to innovative openings, gardens sunrays and overlooking the seafront to enable the largest number of buildings to enjoy the great view to water (Figure 11). An appropriate equilibrium has been achieved between public areas and buildings, built upon the Green City's compact strategy [47]. The existence of public areas with walkaways surroundings landscape and seafront give the neighborhood special ambiances and the density equivalent to that of downtown Stockholm, provides a great quality of life [48]. The city offers many services like commercial buildings, library, a center for Stockholm School of arts, churches, pre-schools, schools of mandatory and upper secondary levels, and a retirement home and healthcare institutions are centrally situated within the neighborhood. Also, there are many entertainment areas like parks, canal, sports center and ski resort. The buildings represent various architectural modernist program applications, light-colored plaster on facades, and using sustainable materials in buildings' exterior and interior, such as stone, wood, glass, rock and steel [46]. Additionally, energy technologies are used like solar cells and panels, which were placed on various roofs and façades to supply the required power for buildings and produce per cent of the annual hot water needs in buildings [47]. The necessary energy and electricity consumed in buildings is generated from renewable resources. The sedum-covered green roofs clear on many buildings are constructed for rain water collection, suspension and evaporation. Plants also contribute to thermal insulation and simultaneously, produce vibrant green spaces within the urban landscape. There have been significant investments in public transportation, with a target of 80 per cent of travel for residents and workers by public transit, bicycle or walk. Well-designed bus lines, ferry service and light rail line lead directly to the city of Stockholm and electrical vehicles may be charged out of the glashusett information center as well as in some garages. Hammarby Sjostad set stringent environmental standards for technical systems, construction, and circulation, also developed new embedded environment alternatives [48]. Waste water and treated waste could produce cooling, heating, biogas and electrical power. Rainwater from roads, after being treated, and rainwater from courtyards and roofs are performed into the lake. Wastewater sludges and food waste are biodegraded into biogas that can be utilized by buses and digested mulches served as fertilizers. Any materials, which may be recycled like glass, papers, plastic and metal are sent for recycling and hazardous waste is collected and sent to landfill. The reuse and enhancement current infrastructure save the utilization of natural resources, reduces the requirement to financial invest and strengthens development potential within the city [49].

Hammarby Sjostad district is considered a successful model of sustainable and resilient urban planning, its concept of a closed-loop system where water, waste & energy are integrated into one system have several positive effects. This model is a combination of urban functions for efficiency, innovation and environmental improvement and its learned lessons can be implemented in other cities around the world.

Figure 11. Building's facade and outdoor spaces

4.2 Paris

The city of Paris, the capital of France, situated in the north-central part of the country, in an area of more than 105 km^2, as shown in Figure 12. It is one of the major European cities and a global center of finance, diplomacy, commerce, fashion, gastronomy, culture, science, and arts. Its cityscape is crisscrossed by wide boulevards and the river Seine, it constitutes one of 8 sectors within the Île-de-France administrative region where is a central location in a rich agricultural area. Paris is unarguably one of the most beautiful and attractive cities in the world, beyond such landmarks as the Eiffel Tower and Gothic Notre-Dame cathedral, it kept its sobriquet "the City of Light" and its importance as an educational and intellectual research centre [50]. In 2015, Paris approved an adjustment strategy which set the base for a more resilient region.

Figure 12. Paris

4.2.1 Paris resilience agenda

With a focus on resiliency, Paris creates a new strategy of urban development, which is adjustable, resourceful, effective and flexible to dangerous global changes. This city has become a worldwide leader in adapting climate and combating exclusion. It attempts to transform the century's challenges to chances by depending on the inhabitants, adapting the infrastructures, mobilizing the collective intelligence and surrounding areas [51]

This city acts on several fronts in response to priority issues. Numerous cross-cutting strategies and public policies were developed for reducing and adapting to climate change, improving environmental quality and mobility, increasing biodiversity, improving opportunities for inhabitants throughout arrangement, strengthening social consistency and support among generations and areas, promoting responsible systems of consumption and production and supporting a circular economy. The resilience strategy, as shown in Figure 13, is based on these actions, it is aimed at improving existing policies and measures, maximizing co-benefits and pooling resources, which provide that shared agenda.

The process of developing the strategy classified six key challenges that influence Paris's land and resiliency: social, economical and spatial inequities and community cohesion, terrorist menace and security framework, climate change, air pollution as an environmental health issue, hazards related to the Seine River, and local governance. The challenges, objectives and actions of the strategy for more resilient city are presented in four parts, which correspond to four requirements and scales of intervention: protecting Parisians against extreme climate events, ensuring the supply of water, food and energy, living with climate change, more sustainable city planning and fostering new lifestyles and boosting solidarity. Thus, this Strategy proposes a resilient approach to strengthen

Paris' solidarity with its districts, resulting in a resilient metropolis and provides the city a framework for action plan that has 3 main pillars [51]: Pillar 1 is making a cohesive, inclusive city that shapes on its inhabitants' strength to be more resilient. This approach should be inclusive, as everybody is involved: private investors, public agencies, organizatio ns, residents, city's users and researchers. The greater the inclusiveness of a society, a greater its unity and solidarity, and a greater its cope with every eventuality, both on a daily basis and in an emergency. Pillar 2 is building and developing city tackling the twenty-first century's issues. Resiliency requires an alternative approach to urban areas as well as facilities addressing problems in a comprehensive, tactic and flexible manner: Integrated, to deal with all hazards simultaneously by realizing long-term advantages. Tactic, as small-scale actions may contribute wide and ambitious objectives by exploring new fields. Flexible, as public spaces, buildings and heritage sites are every place of innovation, shock absorption and reaction to the unpredictability in a densely populated city, through changeable, adaptable or momentary results. Pillar 3 is mobilizing collective intelligence and adapting its activities by organizing the collective intellect of inhabitants, organizations and companies to bring about change throughout innovation and collaboration, organizational change and collaboration with neighboring areas and it is needed to ensure that the resiliency effort reflects the issues [52].

Figure 13. Paris strategy [51]

In order to cope with the new stresses and dangers that the city is currently confronting, Paris and its metropolis makes new plans in various areas: energy, urbanism, transport, mobility, infrastructure, networks, equipment, social, parks, street design, changes in the thinking of the land management and the future for creating a resilient community, enhancing the quality of life of its citizens, protecting from risks and providing an optimistic upcoming perspective. Actions to achieve the resilience's objectives involve the use of schools as an oasis of cooling during heat waves; the creation of a resilient and carbon-neutral district in St-Vincent de Paul. Also, the use of solar panels in buildings and outdoor spaces; the use of green walls and roofs in different types of buildings and the use of light paintings in the building facades (Figure 14). Additionally, the transformation of Parisian ring road; the development of the streets, places and squares and the improvement of the sustainable street furniture. Moreover, the support of measures to adapt to climate change in relation with the Seine for improving the quality of water and preventing flooding [52]. Paris benefits from the support for the 100 Resilient Cities program of the Rockefeller Foundation to increase resilience level of the city [53]. With the Paris Resilience Strategy, the city is moving toward significant urban resilience through plans, which consider the whole urban eco-system of the city. By implementing this strategy and its integrated solutions, it develops a comprehensive approach involving interventions, which increase urban assets and offer many benefits and it may act as a strategy for cities throughout Europe and worldwide.

Figure 14. Street design and green walls

5. PROPOSED BUILT ENVIRONMENT URBAN ENERGY RESILIENCE FRAMEWORK

According to the preceding analysis for resilient cities and the energy urban planning models suggested by different planner experts and organizations, the built environment's components in these frameworks have several expressions that vary from framework to another but have almost the same meaning. The analysis of previous frameworks was composed in a matrix as shown in Table 1 where rows include the main built environment 7 components, collected from previous frameworks and columns represent the previous organizations and cities showing their all built environment subcomponents.

Then, building a proposed framework which summarizes the previous subcomponents, in Table 1, that are necessary to consider when planning the built environment in the context of energy and respecting the urban resilience principles: robustness, resourcefulness, efficiency, diversity, flexibility, mobility, creativity, equity, and identity which are related to the components of the built environment that stress on the adaptation of energy.

This resulted in a framework built on a 100 point scale as shown in Table 2 where rows represent the main built environment components which are urban morphology, land use, buildings, infrastructure, transportation, energy and waste concluded from the several frameworks and columns include the built environment subcomponents selected for each component which are the following: the urban morphology consists of density, urban pattern and mass and the buildings comprise the buildings material, form, height, green roofs, facade and envelop treatment. Additionally, the land use covers mixed use, outdoor spaces, green areas and reuse of development land, as well, the transportation encompasses pedestrian circulation, public transportation, private transportation, travel time, cycling and parking. Moreover, the infrastructure includes roads networks, sidewalk and street lighting, and the energy involves developing and using renewable energy. Besides, the waste incorporates decrease, re-use, recycle, environmentally sound disposal. This model is essential to appraise the energy system in order to achieve energy resiliency in the built environment. The concluded built environment criteria for energy vulnerability are described below:

Table 1. Analysis of previous frameworks

FRAMEWORK COMPONENTS	ORGANIZATIONS				EXAMPLES	
	MED-ENEC	UNHABITAT	WORLD BANK & ESMAP	UNDP	HAMMARBY	PARIS
URBAN MORPHOLOGY	Massing Parcellation Topography Climate Framework	Urban design	Urban pattern Compact masses Green areas Climatic conditions	---	Density, block sizes, street dimensions, compact Environmental solutions, biodiversity	Inclusive, Flexible innovation Carbon neutral district, Environmental health adapt to climate change, biodiversity
BUILDINGS	Building types Architectural elements	Architectural design	Form Material Environmental treatment	Construction green roofs installation, climate-adaptive architecture Green principles and measures	Sustainable materials orientation, light color paints, big windows height, green roofs, courtyard	Green walls, color paints
LAND USE	Layout, Zoning Density, Mobility accessibility Outdoor spaces	Open spaces	Mixed use Density parks Facilities Amenities	Urban forest conservation, wetland restoration/ construction crop switching rotation, erosion control minimum tillage, aquaculture diversification	Parks, Many activities. services	Land management, Places and squares, Public spaces, develop agriculture lands
INFRASTRUCTURE	---	Use Cycle treatment	Road Street network	Blue and green infrastructure construction, Street lighting water pumping rainwater harvesting wastewater recycling	Street furniture and dimensions, Reuse rainwater, Sewage	Street design technology Quality of water, Amenities
TRANSPORTATION	---	Transport Accessibility	Pedestrian network	Non-motorized strips and public transit infrastructure construction, green clean transport, development access to mobility	Walkways, public transportation, Walking, bike routes travel time, Eco ducts	Reduce congestion Street design, improve networks
ENERGY	Flexibility integration	Consumption Production Efficiency	---	Development/use of renewable energies (biomass, solar, wind) Thermal (Solar Water Heating) Waste to Energy (Agriculture/Biogas)	Renewable resources, Solar panels, fuel cells	Renewable Energy plans solar panels
WASTE	---	Recycle reuse	---	Reduce/ minimize, re-use, recycle, environmentally sound disposal Waste Management	Biofuels food waste Hazardous waste, reuse waste, produce electricity, heating and cooling, collection recycling waste	Zero waste plan Food waste reduction, recycling Treatment Waste management

Table 2. Proposed framework

FRAMEWORK COMPONENTS	FRAMEWORK SUBCOMPONENTS							AVAILABILITY PERCENTAGE
URBAN MORPHOLOGY	**-Massing -Parcellation**	**-Topography -Climate**	**-Inclusive -Identity**	**-Biodiversity design -Layout**	**-Density -Block sizes**	**-Urban pattern -Compact masses -Carbon neutral district**	**-Creativity -Adaptive urban form**	
BUILDINGS	**-Green principles & measures -Architectural design**	**-Architectural elements -Height**	**-Form -Building types**	**-Courtyard -Climate adaptive architecture**	**-Materials -Orientation -Façade elements**	**-Green walls /roofs -Light color paints**	**-Insulation -Environmental treatment**	
LAND USE	**-Zoning -Public spaces**	**-Facilities -Activities**	**-Diversity -Mixed use -Aesthetics**	**-Parks & green areas -Street furniture**	**-Activities -Robustness**	**-Social services -Outdoor materials**	**-Agriculture lands -Land management**	
INFRASTRUCTURE	**-Amenities -Smart**	**-Sewage -Use Rainwater**	**-Road design -Street network**	**-Pavement -Equity**	**-Sustainable**	**-Technology -Storage facilities**	**-Water -Electricity**	
TRANSPORTATION	**-Improve networks -Reduce congestion**	**-Accessibility & mobility -Street design**	**-Pedestrian network -Safety**	**-Bike routes -Green clean transport -Modes**	**-Walkways -Travel time -Affordable**	**-Public transportation -Private transportation**	**-Non-motorized strips -Parking**	
ENERGY	**-Efficiency -Integration**	**-Consumption -Production**	**-Biomass -Fuel cells**	**-Wind -Waste to Energy**	**-Solar panels -Resourcefulness**	**-Renewable Energy -Equity distribution**	**-Flexibility -Creativity**	
WASTE	**-Environmentally sound disposal**	**-Collection -Zero waste**	**-Waste management**	**-Minimize -Reuse**	**-Recycling -Reduce Food waste**	**-Municipal solid waste -Hazardous waste**	**-Treatment -Emission control**	
								Total /100

5.1 Urban morphology

The components of the urban morphology and its subcomponents comprehend some criteria which are designing for adequate densities, providing a diversity of uses and masses, building pattern with irregular open spaces and well arranging and orienting the building and streets in the urban pattern.

5.2 Buildings

The building component and its subcomponents include numerous criteria that must take in attention when designing such as the compact form of the building, the lower surface and roof volume ratio, the well orientation of the building, the use of insulation material and local light color material, the optimize of the opening ratio, the respect of the height to width ratio, the ad of shading device, green area in roof and the integration of photovoltaic cell.

5.3 Land use

The land use component and its subcomponents cover several criteria that must take in consideration when planning such as the diversity and multifunction of the uses, the flexibility in reusing land with the integration of renewable energy, the use of porous and light color material in the outdoor spaces and the use of vegetation and soft landscape.

5.4 Transportation

The transportation component and its subcomponents encompass several criteria that must take in consideration when planning such as the availability of the mixed uses to decrease the daily time travel, the diversity of the mode of transportation with increasing the share of public transportation, the location, size and number of parking lots, the shaded, safe and comfort sidewalks for pedestrian and lane for cycling, the design of the appropriate distance needed for each mode of transportation and the reduce of the private transportation usage.

5.5 Infrastructure

The infrastructure component and its subcomponents comprise different criteria that have to be considered when designing such as the color and the materials of pavements, the connectivity, size and function of road and street design, the integration of the suitable renewable energy for the selected area to be applied with taking in consideration the location and size of storage and the selection of the efficient street lighting unit.

5.6 Energy

The energy component and its subcomponents encompass opportunities for an environmentally friendly, long-term energy supply should be developed towards the usage of renewable sources such as solar, water, biomass, wind, hydrogen, geothermic, and fuel cells. These sources protect negative against negative impacts on energy supply, prices and environmental issues and prevent the resources' consumption and environmental degradation by pollutant releases, petroleum leaks or poisonous spinoffs. Developing renewable energy resources encourages the sustained use and productivity and breaks the linkage of resources' consumption and production.

5.7 Waste

The waste component and its subcomponents comprise different criteria that have been considered when designing the waste systems that can use sustainable solutions, support increased utilization of alternative energy resources and more energy saving actions for transportation and buildings, recycle waste and water, and utilize greenery for pollution filtration and CO_2 capture. It is linked to redefine waste streams as 'resource streams' for example wastewater reuse; reducing, reusing, treating waste, recycling construction, demolition and household wastes; and converting waste to energy.

6. CASE STUDY: NEW BORG EL ARAB CITY IN ALEXANDRIA, EGYPT

Recently, Alexandria in Egypt is facing a severe energy shortage. As its current energy consumption is irrational and unsustainable, there is a dire need to develop a resilient built environment for energy vulnerability to meet the demand of users. The case study of Borg El Arab is a new urban community, one of Alexandria Governorate's new growth poles (Figure 15), situated 60 km from Alexandria and 7 km from the northern coast in Egypt [54].

The city was established by decree of the President of the Republic Number 506 of 1979. It is divided administratively into13 districts and its total area is 47403 acres with a population of 170000 inhabitants as population density is about 3 people/acres [54]. It has a hot arid climate as it is extremely hot in summers and cold in winters. This new city was selected specially as it still has new areas to progress so evaluating the current resiliency situation and offering recommendations could modify the exiting condition and support it with the newly developed phases.

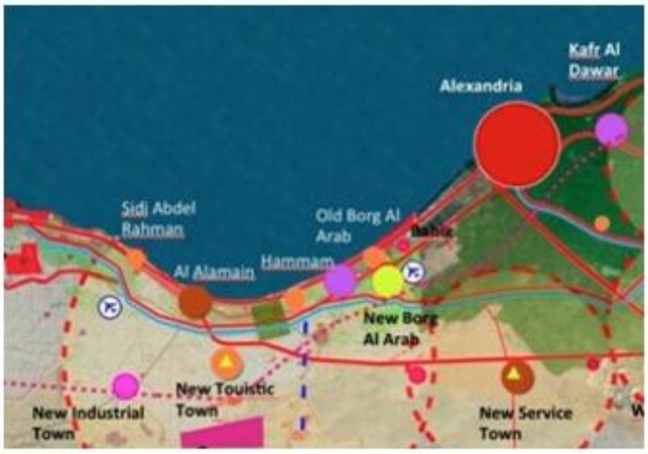

Figure 15. Location of New Borg El Arab City [55]

Borg El Arab is an active area and currently home to several growing industries, where its total energy consumption is increasing gradually in the last years [56]. So, it is essential to study the energy system in Borg El Arab built environment. Therefore, to deal with the extremely high demand of energy and achieve energy resiliency and improve quality of life in Borg El Arab, it is important to survey and analyze its built environment and energy system based on the energy criteria and principles of the built environment components discussed previously.

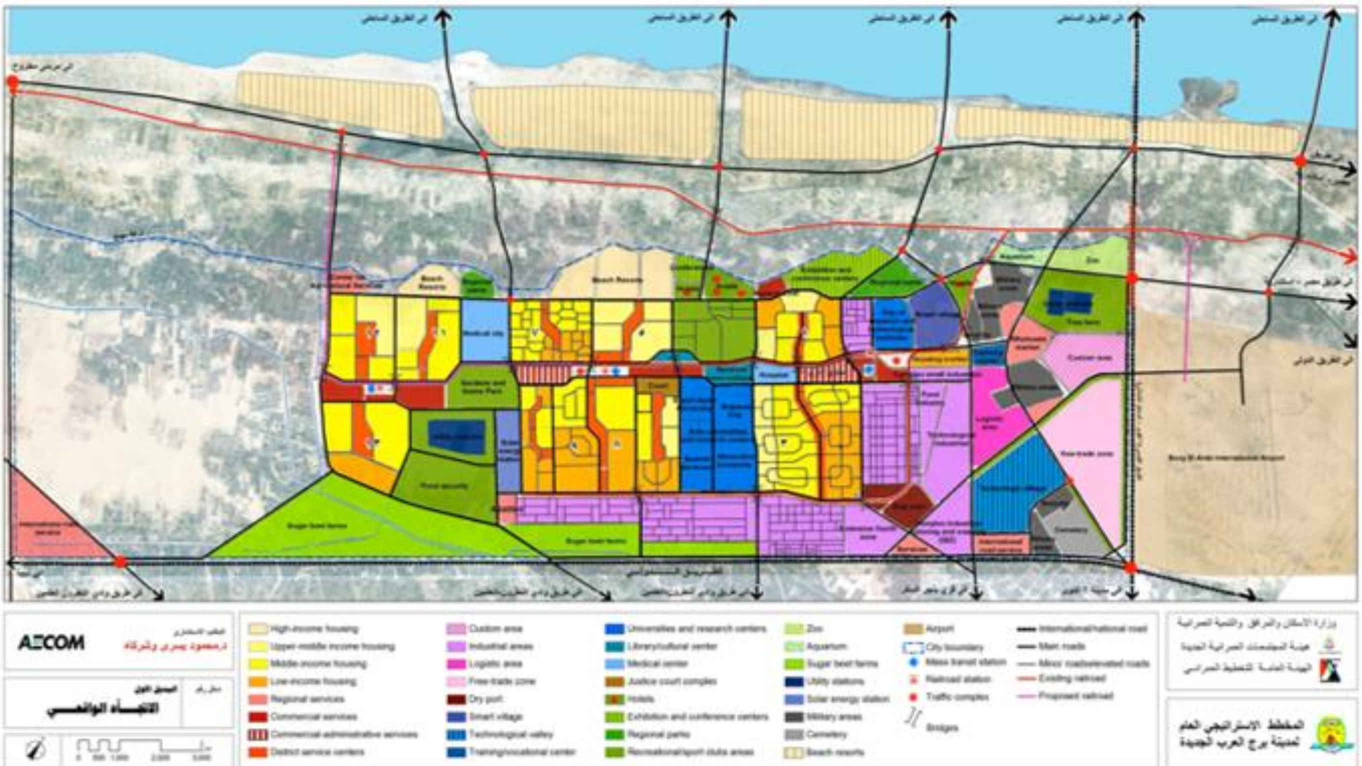

Figure 16. Master Plan New Borg El Arab City [54]

6.1 Borg El Arab urban morphology

The urban morphology of Borg El Arab, as shown in Figure 16, has an indirect impact on the consumption of energy. The analysis of its urban pattern and masses clarify its importance and impact on the energy resiliency. Borg El Arab is a positive grid urban fabric with low density. Its urban pattern and main streets are oriented to the north-south to provide free channels for wind and to accommodate the prevailing winds to reduce heat gain and encourage natural ventilation for public space and built up fabric that promotes the principle of efficiency. Additionally, there is a clear connection and network of roads and streets that improve diversity and equity of accessibility and have a good influence on driving and walking patterns. The urban pattern of Borg El Arab plays a vital role to achieve significant energy efficiency as it has a notable site location and its layout is oriented to the most recommended direction to capture the maximum amount of wind to improve natural ventilation and in turn reduce the energy consumed for cooling.

Borg El Arab plot fabric is flexible enough to accommodate a diversity of building types and green spaces (Figure 17). Therefore, the buildings mass size which are compact and physical arrangement influence on the indoor and outdoor climate as they increase shading and natural ventilation, which in turn decrease the cooling load and provide a suitable comfort environment for pedestrians in outdoor spaces. Building masses pattern are dispersed with irregular open spaces to provide continuous air movements and optimize daylight penetration, sunlight exposure and shade to all buildings that increase energy efficiency and outdoor spaces in order to provide a better energy performance in the built environment.

Figure 17. Urban pattern of New Borg El Arab City [55]

6.2 Borg El Arab buildings

Borg El Arab contains various types of buildings with no specific architectural styles (Figure 18). The forms of buildings are compact with lower surface-volume ratio, small surface area and flat roof which result in lower internal cooling loads and solar heat absorption which in turn promote the efficient principle. In addition, there are different forms of building shown in Figure 18 such as the rectangle form with small surface area, the L-shape building that creates a comfortable shaded area because the open side is good orientated and the T shape building that is the most form used which offers two shaded outdoor spaces with different orientations. The buildings' heights of Borg El Arab vary from 2 to 10 floors. Despite of the variation of Borg El Arab buildings heights, the average dominant height of the buildings are 5-6 floors that show the alignment of the building sky line and represent approximately 95% of Borg El Arab buildings which have a low surface area that help to minimize heat gain. In addition, the proportion of height to width ratio of the street canyon is about 1.2 that improve the wind flow to provide a good ventilation and natural lighting in order to increase the energy efficiency principle in the buildings.

Figure 18. Buildings in New Borg El Arab

The building materials used is the same in all Borg El Arab buildings as the construction material is concrete and red brick painted with light colors such as off-white color and some parts are covered with brick cladding that decrease the flow and transformation of solar radiation and its reflection. Although, the material and the color of buildings are suitable for the climatic conditions but there is no insulation material and the glass used is the 6mm single-pane glass that permit heat transfer in the buildings which in turn increase the energy consumption for cooling. In addition, the wooden window shutters are used to help control light, give privacy and help to reduce the electricity consumption. The building envelope designs of Borg El Arab respect some of the built environment resilient criteria such as of the color of the façades are suitable and avoid glare caused by solar reflection. Thus, the window allowing sufficient daylight and natural ventilation also the window wall ratios exceed the maximum ratio which is 18% to minimize the heat gain. Moreover, the window shading concepts are designed in buildings as vertical shading device and wooden shutter window are used in the north elevation and in the south façade the openings are small and the horizontal louvers are applied. There are a lot of air conditioning systems attached to most buildings, which add load heat to the open spaces.

6.3 Borg El Arab land use

Borg El Arab has a diversity of land use which promote the principle of diversity (Figure 19). There are 30000 acres for built-up areas which are residential, service, industrial, tourist and recreational areas. The residential uses represent the major built area of Borg El Arab and there are also a lot of activities and services. The total number of housing units implemented in the city is 45054 units which comprise several types and levels of residential buildings [54].

There are many service activities as 109 service buildings implemented by New Urban Communities Authority as follow: 1 cultural building, 1 industrial service building, 1 communications building, 3 sports buildings, 5 administrative buildings, 22 social buildings, 9 religious' buildings, 9 public services buildings, 10 medical buildings, 12 security buildings, 13 educational buildings and 23 commercial buildings. There are other 82 buildings that were implemented by other authorities, including: 2 railway Stations, Azhar Institute, Japanese University, Borg El Arab Stadium, City of Scientific Research and Technological Applications, Central Security Camp, traffic administrative building, banks, Gas company building and Building belonging to the ministry of justice, in addition to 83 service buildings built by the private sector. There are productive factories and small workshops that reached 10194 with an invested capital of 132.5 billion pounds with an annual production of 140 billion pounds [57].

Figure 19. Land use in New Borg El Arab

The green areas and the outdoor spaces are widely spread in some districts such as first, third, fourth and eighth districts in Borg El Arab and other districts have few trees and green spaces. They ensure comfort and are important to maximize the natural ventilation, shading of streets and outdoor spaces for pedestrians, therefore they could be used for a variety of uses for the residents and visitors in some districts where to street furniture are placed including green areas, table, seats, shades, fences and some decorative lighting units. There are a lot of green areas as each group of apartments are clustered and surrounded by green gardens that make use of passive solar and wind conditions, contributing to cooling efficiency by reducing solar heat absorption which in turn reduce the energy consumption. The green areas within the open space are well oriented to provide shade for the ground floors in buildings and protect them from direct solar radiation to reduce the energy consumption needed for cooling, to enhance the weather condition and reduce humidity for the residents.

6.4 Borg El Arab transportation

There are many private transportations as well as public modes of transport in the city such as a railway linking the new city to the Alexandria governorate, buses to transport residents to and from the train station, 5 buses to serve the citizens of the city and a minibus station served by 500 minibuses to connect the new city with neighboring villages and cities [56]. Also, Borg El Arab airport is near the new city. Borg El Arab is characterized by a good pedestrian network supported by the diversity of uses that encourage residents to access services and amenities easily without depending on private cars that provide flexibility in movements and some districts use bicycles. Walking and cycling reduce air pollutions, reduce indirectly the energy consumption in Borg El Arab built environment and the heat gain by minimizing the use of vehicles which in turn promote the principle efficiency and safety. The pedestrian walkways in some parts of Borg El Arab are pleasant and attractive (Figure 20). They include some important friendly designed elements such as different kind of vegetation, trees and palms that provide shade to pedestrians and create a comfort buffer from the street which encourage walking and in turn reduce energy consumption due the shading of the vegetation on the sidewalks and the reduction of the heat gain in buildings. Also, there are some shaded seats and water features to support the pedestrian movement. As a result, enhancing the pedestrian circulation lies to increase the energy efficiency. The bicycles are used fewer in Borg El Arab as it is a closed built environment suitable in some areas for their residents to cycle but there is no clear or specific lanes and parking for bicycles, thus, the bicycle users' ride in the same lanes of vehicles or pedestrians.

Figure 20. Pedestrian walkways

6.5 Borg El Arab infrastructure

Borg El Arab is an active city and has the basic infrastructures. The electricity networks are with a length of 2512.60 km and stations with a capacity of 325 MVA were implemented to meet its need of electricity. The city has access to pure drinking water through the drinking water purification plant and its expansion from 40 Km Alexandria-Cairo desert road through three lines with diameters of 1000, 1500, 1500 mm to the drinking water lift station in the city and the tanks capacity is about 40000m^3. Water networks are with length of 1521.6 km and the city's lifting station is with a capacity of 166000 m^3/day and the average daily income for the city ranges from 100000 to 120000 m^3/day [57]. A sewage treatment plant (oxidation ponds) with a capacity of 46000 m3/day has been implemented, and is being developed and expanded with a disposition of 54000 m^3/day to reach the total capacity of 100 thousand m^3/day. The sewage networks have been implemented with a length of 446.007 km. Furthermore, the communication networks were finished with a length of 777 km with 5 lifting stations (Figure 21).

Figure 21. Sewage station [57]

Also, the road networks were implemented with a length of 630.75 km including afforestation of roadsides. Additionally, the pavement has an indirect impact on the energy by improving the urban microclimate conditions and comfort in open urban areas which in turn help to reduce the cooling load in buildings. Borg El Arab contains a good network of roads and streets that connects all its districts and parts together and comprises many types of street lighting units that its consumption of electricity increases yearly. The roads are divided into main road and secondary roads. Different materials are used for streets in Borg El Arab as the vehicle roads are covered with asphalt, pedestrian sidewalks are paved with light-colored materials suitable for users that low the outdoor ambient temperature and outdoor spaces are paved with square light-yellow red cement pavement tiles which limit the absorption of solar radiation and avoid glare for pedestrians.

6.6 Borg El Arab energy

Borg El Arab city depends on several resources to gain energy. Its energy mainly comes from the electricity network with length 2100 km, stations capacity is 325 MVA, with 87 transformers and 19 distributors. Also, there is gas network with length 101 km, stations capacity is 100 thousand m^3 / hour and 12 regulators. In addition, there is a multi-purpose solar power plant station generates five megawatts of thermal energy, one megawatt of electrical energy, and two hundred and fifty cubic meters of desalinated water from salt water daily by employing the latest technological applications in the fields of new and renewable energy (Figure 22). Borg El Arab consumes a great amount of energy due to the large number of factories and public buildings, which in turn faces an energy shortage

Figure 22. Solar power plant station [54]

6.7 Borg El Arab waste

There are many waste sources from factories, hospitals and residential areas as construction, industrial and household waste. Management waste system for municipal solid waste from homes is by assigning companies working in the field of hygiene, collecting by covered transport vehicles that operate by mechanical pistons and handing it over to the sanitary landfills in Alexandria Governorate. Management waste system for Hazardous medical waste from the medical buildings is disposed by the health administration through transportation and safe disposal in a medical waste incinerator. The disposal of Hazardous industrial waste is done by collecting, transporting and delivering to the safe disposal and approved waste landfill in Nasiriyah. The household wastewater is treated in sewage treatment plants and the reuse of waste water is used for agricultural drainage system and irrigation of green areas and trees.

6.8 Energy resilience framework of Borg El Arab

After surveying and analyzing the energy in the built environment of Borg El Arab, the proposed resilient built environment framework for energy vulnerability is applied on Borg El Arab built environment. Table 3 summarizes the appraising of the energy in Borg El Arab built environment according to the resilient built environment criteria for energy vulnerability and to identify gaps. The framework acts as baseline study to appraise the energy resilience of the built environment using quantitative method with total 100 points (each subcomponent has 1 point).

This table illustrates the degree of resilience performance for Borg El Arab as by calculating the results of the framework, it concludes that the new city achieves 65% of the suggested resilience criteria.

From this framework, it is determined that there is a good diversity of uses, alternative roads and streets, building types and transportation paths and mode. Furthermore, the efficiency principles are promoted in the buildings, urban morphology and transportation. Despite Borg El Arab built environment promote some of the built environment resilient criteria but is still need to be developed and upgraded to achieve the energy resilience in its built environment.

Table 3. Framework appraises the energy resilience of the built environment of Borg El Arab

FRAMEWORK COMPONENTS	FRAMEWORK SUBCOMPONENTS							AVAILABILITY PERCENTAGE
URBAN MORPHOLOGY	-Massing -Parcellation	-Topography -Climate	-Inclusive -Identity	-Biodiversity design -Layout	-Density -Block sizes	-Urban pattern -Compact masses -Carbon neutral district	-Creativity -Adaptive urban form	11/15
BUILDINGS	-Green principles & measures -Architectural design	-Architectural elements -Height	-Form -Building types	-Courtyard -Climate adaptive architecture	-Materials -Orientation -Façade elements	-Green walls /roofs -Light color paints	-Insulation -Environmental treatment	11/15
LAND USE	-Zoning -Public spaces	-Facilities -Activities	-Diversity -Mixed use -Aesthetics	-Parks & green areas -Street furniture	-Activities -Robustness	-Social services -Outdoor materials	-Agriculture lands -Land management	11/15
INFRASTRUCTURE	-Amenities -Smart	-Sewage -Use Rainwater	-Road design -Street network	-Pavement -Equity	-Sustainable	-Technology -Storage facilities	-Water -Electricity	8/13
TRANSPORTATION	-Improve networks -Reduce congestion	-Accessibility& mobility -Street design	-Pedestrian network -Safety	-Bike routes -Green clean transport -Modes	-Walkways -Travel time -Affordable	-Public transportation -Private transportation	-Non-motorized strips -Parking	12/16
ENERGY	-Efficiency -Integration	-Consumption -Production	-Biomass -Fuel cells	-Wind -Waste to Energy	-Solar panels -Resourcefulness	-Renewable Energy -Equity distribution	-Flexibility -Creativity	5/14
WASTE	-Environmentally sound disposal	-Collection -Zero waste	-Waste management	-Minimize -Reuse	-Recycling -Reduce Food waste	-Municipal solid waste -Hazardous waste	-Treatment -Emission control	7/12
								Total 65/100

Table 4. Pairwise comparison matrix

Framework components	Urban morphology	Buildings	Land use	Transportation	Infrastructure	Energy	Waste	Priority
Urban morphology	1	0.33	5	3	0.33	0.14	0.33	0.071
Buildings	3	1	5	3	0.33	0.2	0.20	0.096
Land use	0.20	0.20	1	0.33	0.20	0.11	0.14	0.023
Transportation	0.33	0.33	3	1	0.33	0.20	0.33	0.049
Infrastructure	3	3	5	3	1	0.33	0.33	0.145
Energy	7	5	9	5	3	1	3	**0.383**
Waste	3	5	7	3	3	0.33	1	0.233
						Consistency Ratio =0.087		

Then, an AHP method was applied to determine the priorities of its built environment components, which need to be developed in order to achieve a resilient city. Table 4 clarifies that the renewable energy is the major built environment component that should take into consideration to upgrade the resiliency level of New Borg El Arab City as there is a need to face its energy shortage.

7. CONCLUSION

Urban communities remain fragile, vulnerable and exposed to an undefined number of chronic stresses and acute shocks. Chronic energy shortage is one of the major vulnerabilities and constraints which threaten the urban community and its built environment and place pressures on the urban systems, primarily as a result of the effect of increased energy consumption in the built environment. Unfortunately, the current global resources supplying this energy demand are on the decline. Although, the importance of energy for effective functioning of cities, there is still a very limited number of studies of the urban resilience concept and a gap regarding the integration of energy in the resilient built environment.

The resilience concept offers a new perspective of sustainability as is a comprehensive, multidisciplinary and adaptive strategy for the assessment of the shocks related to urban vulnerabilities to cope with unexpected stresses. Recently, applying the concept of resilience in the city and its built environment through its different principles, is urgently needed to face the city vulnerabilities. Resilience provides a critical point of intersection between different but substantially similar paradigms in urban development as well as its importance is growing scientifically and realistically, and its increasing commitment is present in the global engagements related to sustainability and energy efficiency. As Energy is a vital component in modern life and is considered a valuable source for improving the quality of life and satisfaction of human needs, there is a need for a huge amount of energy to support city living and to survive and live comfortably. The Resiliency has to be used as a holistic concept in the context of energy to address the gaps existing in the built environment to resist and manage chronic stress of energy shortage. Resilience considering an energy crisis is the capacity to successfully deal with energy-related vulnerabilities while continuing to deliver energy to the built environment.

In this context, to achieve energy resiliency in the built environment, a literature review was done to identify the energy resilience concepts and principles and an analytical review of a number of energy built environment frameworks from several organizations and top ranked resilient cities has been conducted in order to deduce the built environment components and subcomponents, stress the main weak points in urban areas that increase the energy consumption and shed more light on the potentials and constraints associated with the creation of urban energy resilience. Then, a framework is suggested to appraise the energy system in the built environment respecting urban energy principles. It is categorized into seven components 'built environment which are which are urban morphology, land use, buildings, infrastructure, transportation, energy and waste and each component is then divided into subcomponents that are further related to the built environment. This framework seeks to integrate urban energy and resilience to elaborate on the concept of urban energy resilience to serve for assessing urban energy resilience and to addresses the energy vulnerability in a built environment for enabling planners and decision-makers to better understand and analyze the problems to make the urban communities more resilient.

Borg El Arab has been chosen as a case study to apply the proposed model of the energy resilient built environment to test its validity starting by collecting data, surveying and analyzing the existing condition and then applying the AHP method to prioritize its significances of developing and upgrading the built environment components. By analyzing the case study, it was resulted that Borg El Arab has great potentials as it is well planned, enclosed and low densities of population. Also, it has good network of roads that helps in using green transportation, green areas that can be used to reduce the carbon emission and decreasing the temperature, a variety of mixed uses and great natural resources. Afterwards the proposed framework was used to appraise the energy in Borg El Arab built environment according to the resilient built environment principles and criteria which it was concluded that Borg El Arab is currently falling short of its potential and still need to be developed to be an energy resilient city.

As urban communities are the largest energy consumer globally, the energy system resilience is needed to be applied in the built environment planning for facing the energy crisis fact in any urban areas due to the severe consumption of energy in the built environment. Several recommendations can be suggested to move toward energy resilience in the built environment. The interpretations of such recommendations vary from one built environment to the other, depending on different planning, social and economic factors. these recommendations are the following: planning and developing built environment in terms of energy resilience, upgrading the outdoor spaces, arranging suitable land use., retrofitting the existing building to enhance energy efficiency, increasing the walkability of the built environment, using new energy efficient technology, preparing for the impact of climate change, changing the lifestyle, supporting clean and safe energy generating renewable energy, and finally current studies of urban planning and design have to achieve a comprehensive planning as possible to withstand to energy crisis.

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