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Site & Society Characteristics of Residential Areas Appropriate for Alternative Energy Technology Applications in Egypt

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A B S T R A C T

Energy is one of the most prominent needs of the modern era that all community sectors need to facilitate their daily life. Alternative energy resources are the energy that is not connected to water, electricity, natural gas and petroleum lines or networks. Nowadays, there have been many calls for the use of renewable energy sources to save the usual sources of energy that are depleted by human consumption and cause a great deal of pollution to the environment. However, these sources need equipment and supplies that represent a barrier for many to think about the possibility of their application either for lack of knowledge or the difficulty in predicting implementation scenarios. This research aims to design a map or a traceable scheme to help interested individuals to understand these systems and facilitate their application on a personal level or neighbourhood level by studying the requirements of each of these alternative energy sources, their equipment and supplies needed and prominent site/society features. In response to this challenge, four factors and seventeen (17) subfactors have been recognized to identify characteristics of residential areas appropriate for alternative energy technology. Then, through an electronic questionnaire examined by 25 experts mainly in the field of housing, these factors have been ranked to help decision makers recognize the applicable residential areas for these systems. Finally, some sites in Egypt were suggested as a suitable region. This comes especially in this era in which most of the state's investments are directed towards construction and development, in the residential sector parallel with the repeated calls for reducing energy and using alternative and renewable energy sources.

1. Introduction

Recently, the world has witnessed great interest in renewable energy resources and reducing the depletion on oil, gas and coal resources that will be depleted one day. Thinking about the safety and health of the surrounding environment, carbon emissions reduction and other issues related to sustainable development is also a critical concern. By 2030, thanks in large part to the US Inflation Reduction Act, annual solar and wind capacity in the United States will grow by two-and-a-half-times over today's levels, while electric car sales will be seven times larger. New targets continue to spur the massive build-out of clean energy in China, meaning that its coal and oil consumption both peak before the end of this decade. Faster deployment of renewables and efficiency improvements in the European Union bring down EU natural gas and oil demand by 20% this decade, and coal demand by 50%, a push given additional urgency by the need to find new sources of economic and industrial advantage beyond Russian gas. Japan's Green

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Transformation (GX) program provides a major funding boost for technologies including nuclear, low-emissions hydrogen and ammonia, while Korea is also looking to increase the share of nuclear and renewables in its energy mix. India makes further progress towards its domestic renewable capacity target of 500 gigawatts (GW) in 2030, and renewables meet nearly two-thirds of the country's rapidly rising demand for electricity [1].

Sustainable development is based on two main ideas, achieving the need and the limits. The need to create living conditions to maintain a better and satisfactory standard of living for all people and study the maximum capacity of the environment to meet the needs of the present and future according to the level of technology and social systems [2]. Studies point out that the United States and Europe consume about a quarter of the total energy for heating purposes, while countries in the Gulf, such as Kuwait, consume about 60% of the electrical energy for cooling purposes, and this ratio reaches 90% in Abu Dhabi [3]. At the same time, residential communities in Egypt are in significant expansion at various economic levels, from economic, middle, and above-average housing complexes to premium housing. It is expected to reach 44 new cities by the year 2052 AD [4]. Accordingly, housing patterns varied from buildings to villas, and users' priorities differ in terms of attention to renewable energy resources.

According to Egypt's Vision for Sustainable Development 2030, the Egyptian state paid attention to the housing sector to provide all segments of society with safe and affordable basic housing and services and upgrade slums. Hence, many housing projects have been undertaken in the state, whether economic (social) housing such as Decent Housing projects, Tahya Misr projects, or medium or above-average housing such as Dar Misr or Luxury housing projects as new compounds of New Administrative Capital projects. The state's development in the field of housing, recent interest in renewable energy resources, the absence of data necessary to implement projects based on Alternative Energy Resources (AER.) and their needs, the difference in the social and economic level of individuals, all these factors put pressure on the need to switch to renewable energy resources.

The aim of the research is to determine the characteristics of residential areas that suit AER needs whether solar, wind, bioenergy, water energy, geothermal, or biogas, in addition to wood fuel energy. Application limitations and determinants of these systems were discussed. Specifications of hosted sites with suggested projects were determined. The main question of the study was: Are alternative energy sources suitable for all societies? What are the features of appropriate societies?

That primary aim of the research emerges through an inductive analytical approach that focuses on site and technical requirements in addition to society without delving into financial studies that may be supplemented in future studies.

2. Literature Review

2.1 Previous literature gaps and research contributions

Most previous studies discussed alternative energy technology from several aspects. Some of them dealt with the topic as the source's applications in certain types of buildings like expo buildings, education, public building or healthcare buildings [5], [6]. Other as the influence on the architectural shaping [7], or studying the supporting programs needs to estimate the amount of energy generated by alternative energy systems and their applications in electrification various types of buildings [8]. Some about the technologies developed in architecture to produce renewable energy like integrating photovoltaic cells into decorative architectural facades [9]. All these studies came with no specific attention to the equipment's needs and specifications of the hosted communities. So, it's getting mandatory to discuss these specifications included site capabilities, and the impact on the residents' categories.

2.2 Alternative Energy Sources and Equipment Needs

2.2.1 Solar Energy

The solar energy, among all alternative energy options, is the most abundant, flexible, used and tested. It includes several options:

A- Solar Cells. They are also known as Photovoltaic (PV) cells. These cells convert sunlight into a direct electric current, and they can be relied on in turning on the lighting lamps and small pumps. They have a good shape but relatively high price and its lifespan is significantly varied.

***B- Flat and concentrated connectors*.** They are used to heat water inside copper tubes, which are easy and cheap ways to heat water on surfaces. The concentrated one is a matrix of pipes in a metal box with a concave surface that doubles the efficiency of the system by concentrating the sun's rays on a copper water pipe, Figure 1.

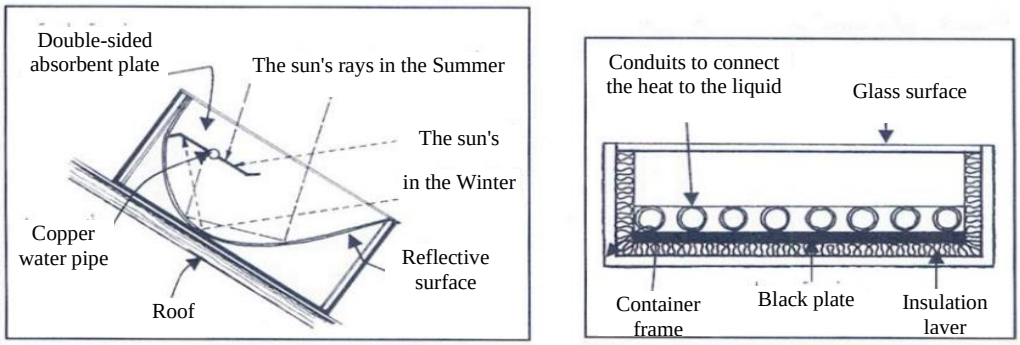


Fig. 1. Flat and concentrated connectors [10].

C- Vacuum tubes. They are a collection of tubes mounted on the surfaces where they absorb the sun's heat and keep it through a reflective surface and pass it after heating the water to a tank. It is a good method with high efficiency but its disadvantage is its relatively high price.

***D- Vacuum convection tubes*.** It is a development of the previous idea. They are a multi-valve and coaxial water heater with vacuum convection tubes connected to a large insulated tank. The sun heats the water inside each pipe, causing it to burst into the supplementary tank. They are characterized by high efficiency in water heating up to the boiling limit, but it is flawed by the large size of the large water tanks and its heavy weight that requires reference to the constructionists to review the loading of surfaces, Figure 2.

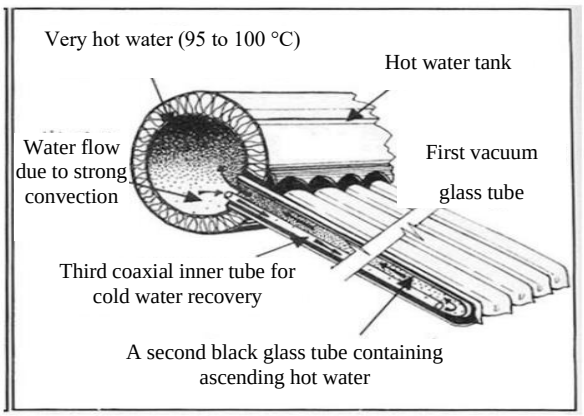


Fig. 2. Heating the water with vacuum convection tubes [10].

E- Passive cooling and heating systems. Among the most famous applications are solar rooms in which the sun angles must be studied in order to establish them and to build them against it. The sun sends its rays on a glass surface, leading to a high temperature of walls and floors. The space between the glass surface and the wall becomes a thermal chimney from which hot air is released. The ventilation holes on the walls and the glass surface are opened or closed as needed. The ventilation holes on the walls and the glass surface are opened or closed as needed, where the air currents rising from the thermal chimney are directed inside or outside the house, Figure 3.

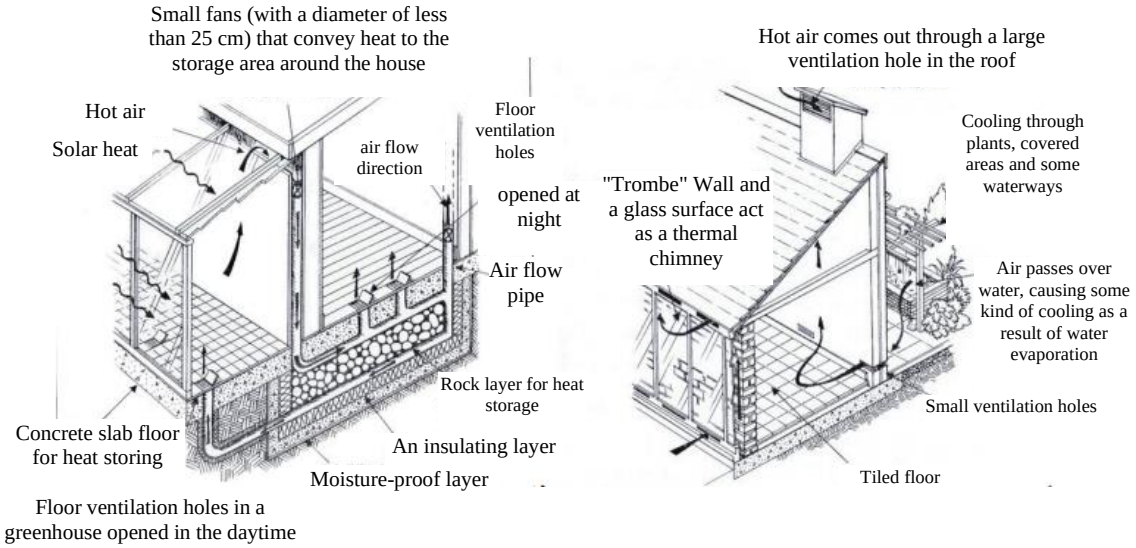


Fig.3. Making use of the sun to provide a heating and cooling system [10].

Thus, the following scheme can be applied to use solar energy, Figure 4:

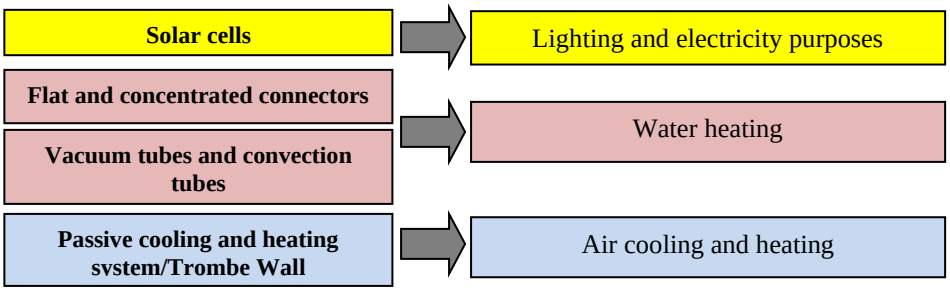


Fig.4. Options for using solar energy.

2.2.2 Wind Energy

It is the energy generated from wind turbines. Turbines are inherently dynamic machines that need to be viewed from many angles such as the study of the visual impact, efficiency, maintenance and the cost of storage batteries. Their types vary according to their sizes and thus their ability to generate electricity as the following:

A- Small turbines. They can be mounted on the highest point of rooftops, with a rotation diameter of approximately 2.10 m, moving at a wind speed of 2.3 m/s, capable of generating power from 500 to 1000 watts.

B- Small independent turbines. They include any turbine that has an independent shaft and is mounted with cables, with a rotation diameter of 3.6 m, its tower height of 8-9 meters, and they can generate power up to 2 KW.

C- Large independent turbines. They include high-tower turbines that can generate electricity up to 3 KW or more, so that they can provide a full-fledged house with an electrical power required in full, but they may require building permits as well as a careful selection of its construction location [11].

The turbines require the following:

- Checking the permits needed to construct them if they are large independent, especially with regard to heights that directly proportional with the wind power [12], Figure 5.

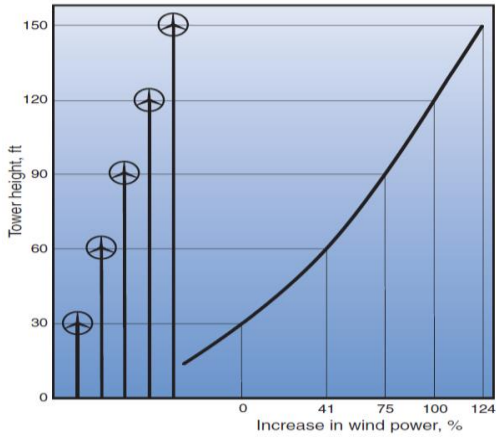


Fig.5. Wind speed increases with height [12].

- Studying site capabilities in terms of area, level, wind speed and existing obstacles, Figure 6.
- Current transformer connected to the main power grid to convert DC to AC before connecting the turbine to the circuit, or storage of the energy generated by the turbine in a set of batteries, and then turning on the lighting lamps and appliances or using them in place heating and water heating, Figure 7.
- Studying the wind speed in the region and the level of construction (on a high area - in low - in a flat area), Figure 8.

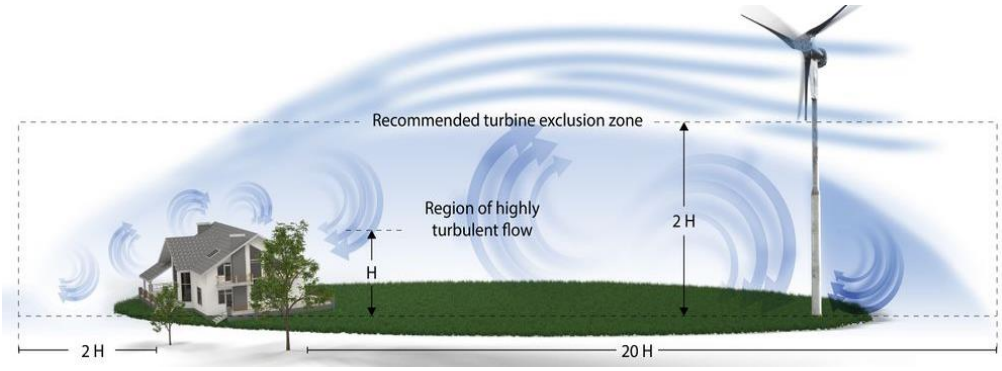


Fig.6. Wind turbines and location capabilities [13].

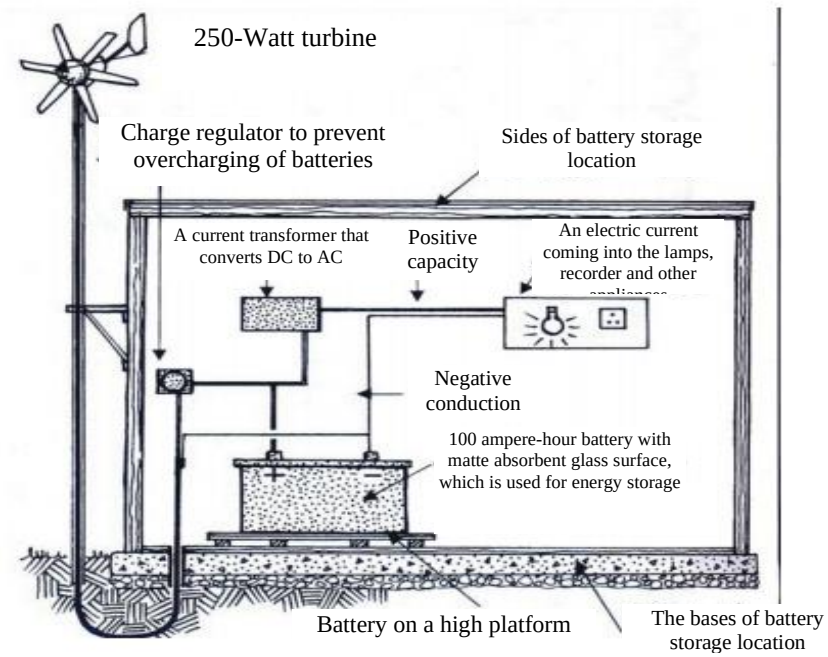
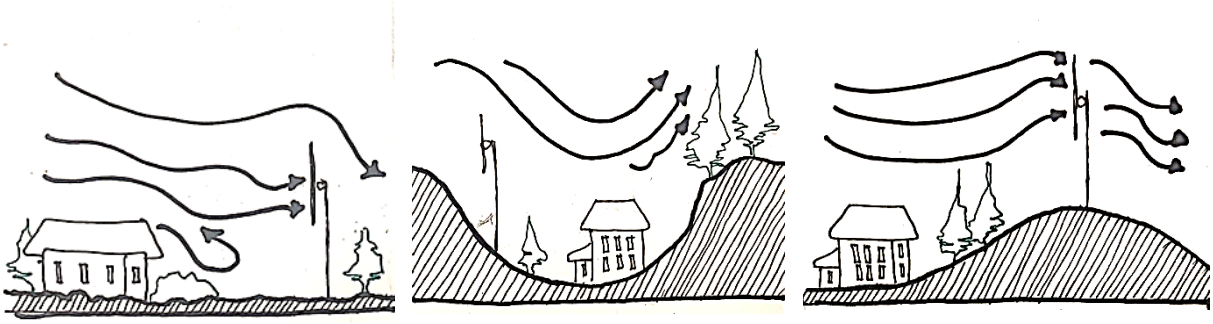


Fig.7. Storage of wind energy in batteries and converting current to AC [10].



A- Good location in a barrier-free area

B- Bad location for a turbine in a windshield valley

C- A typical location for a hilltop turbine

Fig.8. Wind turbines and location capabilities [10].

The combination of wind turbines and photovoltaic cells, for example, is a convenient option for saving energy in all climatic conditions as shown in Figure 9. Turbines are characterized as having a significant impact. When the wind blows and the turbine blades rotate, the energy generated can be felt. It is a dynamic system that is easy to implement at the residential unit level and can be used without batteries to provide appliances with resistors. However, it is preferred to be used with batteries and charging regulator, as well as a 240V voltage transformer connected to the main feeder lines that can run all the appliances that operate with motors or transformers at the house such as TV, recorder, washing machine, dryers, etc., taking into account not all appliances are not turned on at the same time because the turbine will charge the batteries only for a while. The capacity of the batteries should be large enough to be an alternative to the movement of the turbine when it turns off, but they are flawed because they cause noise according to their size [10].

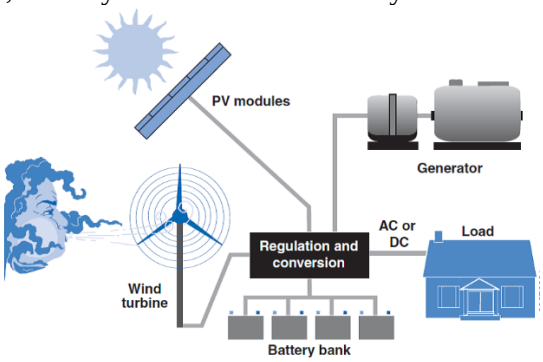


Fig.9. Combination of wind turbines and photovoltaic cells with batteries and converting current to AC. [8].

2.2.3 Wood Fuel Energy

It is an unavailable energy source in many countries due to the lack of wood as a raw material. It is based on burning wood for thermal energy to be used as fuel to turn on an opened or closed fireplace, Figure 10, running ovens and stoves, and water heating. Statistics have shown that the normal fireplace used throughout the year consumes about 17 acres of land planted with trees from which wood used for energy production is taken [14], making it an impractical source at a time when the world is suffering from problems of desertification and pollution.

Fig.10. A modern wood-burning fireplace.

2.2.4 Bioenergy

It is the energy obtained through the chemical treatment of material derived from biological sources. The type of energy produced varies depending on the type of biological sources, for example:

- Biodiesel produced from vegetable oil that is used in refuelling vehicles, for heating purposes, running diesel generators used to generate electricity, and turning on lighting lamps.
- Biogas, as well as fertilizers needed for the cultivation, can be obtained from kitchen waste, toilets and animal manure, with the addition of water through a unit known as the Digester to produce gas for cooking, heating, engine operation and lighting works.

Biogas is a mixture of methane and carbon dioxide that is produced during anaerobic treatment, i.e. in the lack of oxygen, for organic residues. The digester unit is externally equipped through making a hole with a depth and width of 1.8 m and a length of 2.7 m far from house. It is supplied with biological residues, and is covered with a domed gas leak-proof cover, Figure 11. Internal bacteria produce biogas that goes up the digester, passes through a purifier to the house, or is stored in containers for future use. The residues left in the digester are disposed of into a tank where the residues are slipped to be used as fertilizer afterwards.
In order to obtain fertilizer in another way and at the same time to get rid of the residues of organic waste, a fertilizer unit can be made down the house with a ventilation pipe fitted with hoods, and a constant and strong electric current in the region, Figure 12.

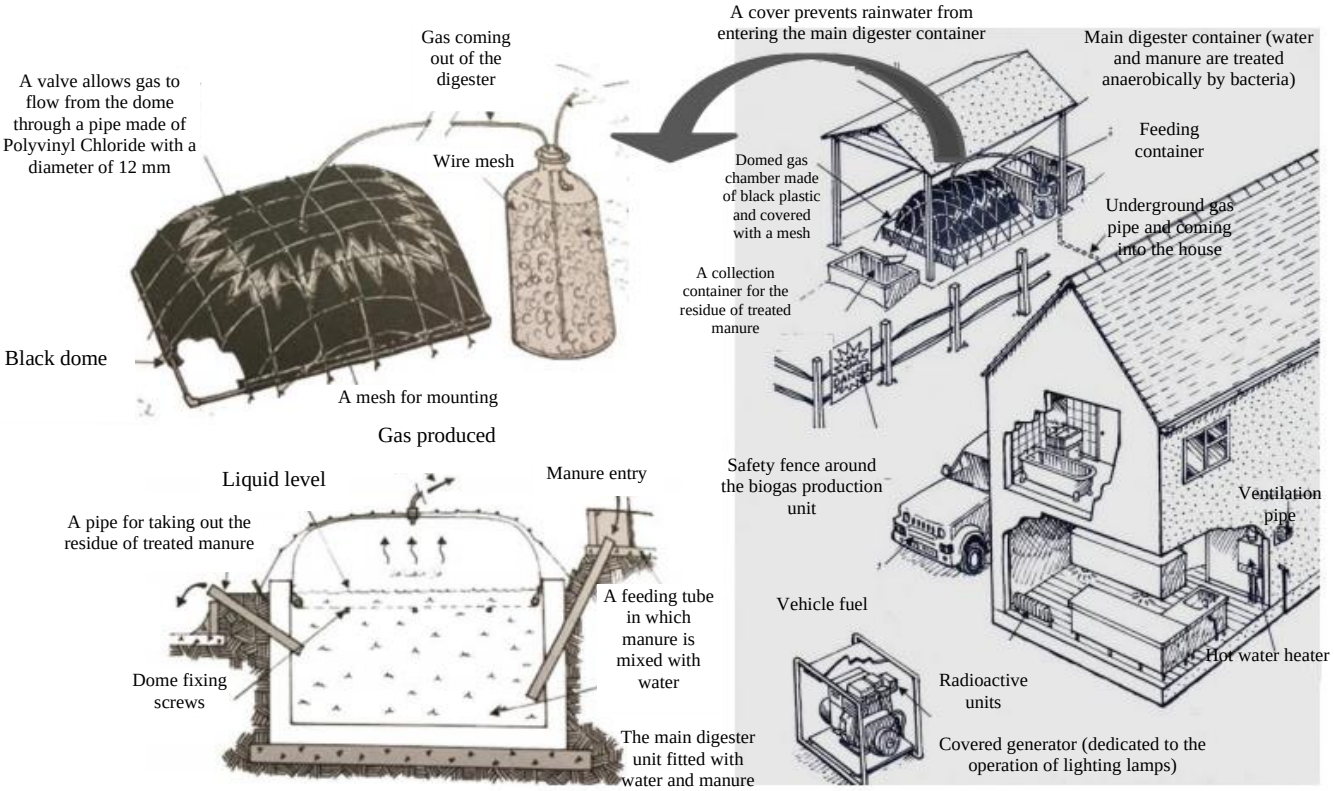


Fig.11. A Household System for Biogas Generation and Uses – Digester Unit Description [10].

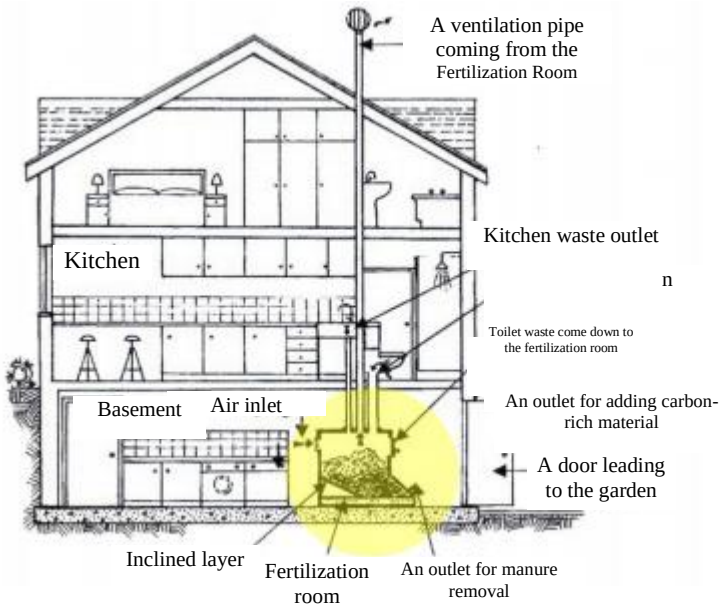


Fig.12. Fertilization unit down a house [10].

It should be in mind that biogas is potentially explosive if mixed with air, and methane can also cause fainting, therefore it is best used for outdoor works such as lighting fences, green areas and animal care purposes. The production of diesel fuel requires strict safety standards, so it cannot be produced in the house basement, for example. It also requires large amounts of vegetable oil to be reused. A prefabricated fuel production unit made up of a used vegetable oil tank, a treatment unit with a heater, a mixing machine, and a fuel tank fitted with a pipe and sprinkler, are purchased. In addition to oil, quantities of methanol and a strong alkaline solution (sodium hydroxide) are added [10]. Thus, Health and safety rules must be followed due to methanol is toxic and flammable, and the alkali solution is caustic. The mixture also produces some toxic fumes.

2.2.5 Geothermal Energy

The energy obtained from the underground by taking advantage of the stability of the underground temperature at a small distance ranging from 7 to 14 ° C. It is one of the best ways among the eco-friendly and more efficient alternative energy systems. It can cool and heat the house in an easy way. It has several types according to operating systems such as horizontal closed-loop system, vertical closed-loop system, spiral closed-loop system, vertical open-loop system, or mounted on a pond, Figure 13.

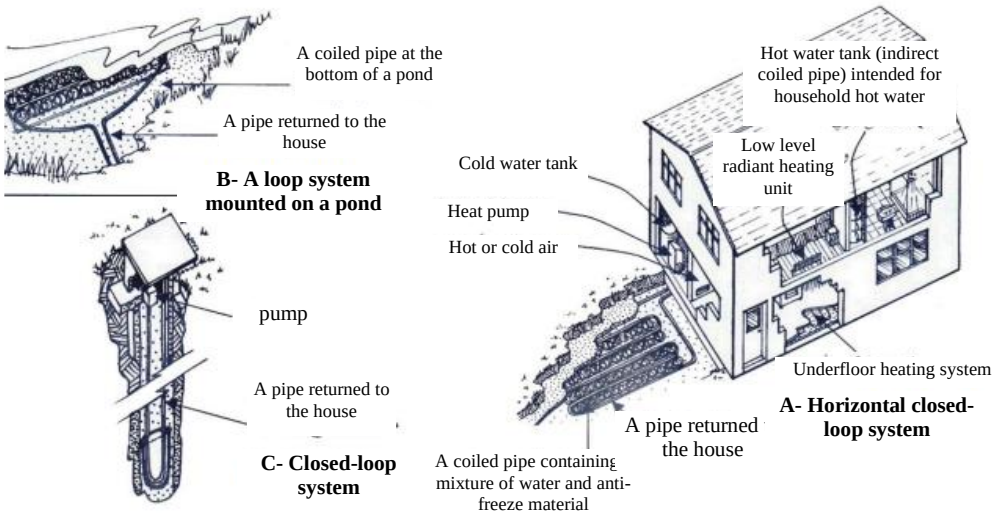


Fig.13. Geothermal energy use systems [10].

It depends in general on digging the ground, either horizontally or vertically (depending on system type) and laying in it coils of straight or spiral pipes that contain a mixture of water and anti-freeze material to make what is known as the geothermal heat pump, which is similar to the refrigerator, where it absorbs heat from one place and move it to another one. The refrigerator also absorbs heat from the food. In winter, the heat pump absorbs heat from the ground and moves it to the house. In the summer, it absorbs heat from the house and moves it to the ground [10].
The difference lies in the shape of the hole in which the pipes are placed, but the vertical is more expensive for considerations of vertical drilling up to large depths of up to 45 meters require excavators, while the other needs a wide horizontal space and a depth of drilling within about a meter.

2.2.6 Water Energy

It is the energy derived from the movement of water whether flow or wave and tidal movement. It is not readily available like wind and solar energy. Either the site has a source of flowing water or not, so that the flowing water is running a turbine or waterwheel, which in turn, they run an electric generator. The smallest type of turbine requires a permanent source of water, in addition to a projector at a height of at least 1.5 meters, so that a unit of this size can generate enough energy to provide the basic energy needed by a small house. It can run some types of heaters and run all appliances, including washing machines, dryers, computers, and others, Figure 14.
Water energy is the least expensive compared to solar panels and wind energy.

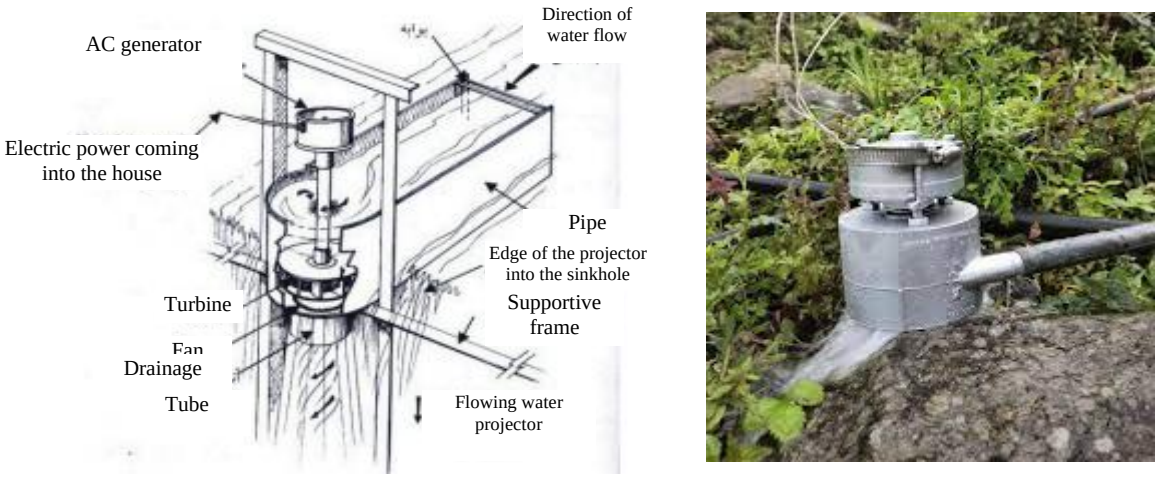


Fig.14. Small Portable Water Turbine [10].

The electric power generated is used in the form of an alternating current or a system that generates electric power in the form of a direct current is used, which is stored in a set of batteries which in turn converts it to an alternating current by using a current transformer.
The amount of electric power generated increases as the projector height or flow rate increases. Simple water wheels, both running by undershot or overshot, can be used to get the same energy from the turbines, Figure 15.

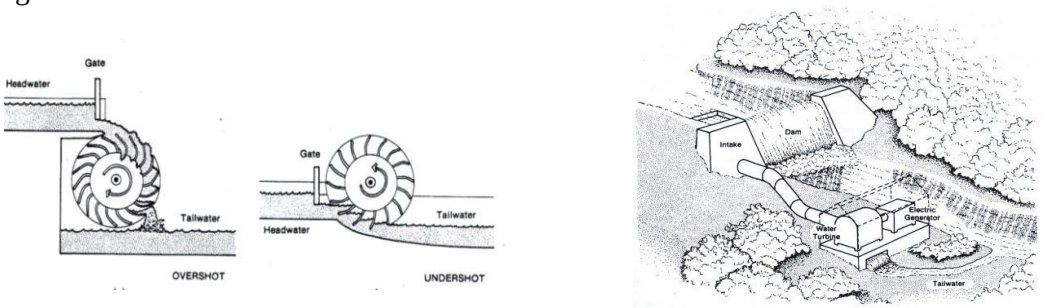


Fig.15. The use of natural watersheds and water wheels by undershot or overshot in the generation of electric power [11].

Tidal energy concern with coastal regions where other marine energy technologies, which convert the energy of waves, tides and ocean currents into electricity, have the potential to provide millions of projects with locally sourced, clean, and reliable energy. This potential could provide cost-effective energy for numerous existing distributed and alternate applications in non-grid connected or remote, coastal areas—including military bases and smaller communities, where electricity costs are high.

2.3 Motivations for Using AER. in Egypt Society

Designers as well as apartment owners may be tempted to consider using alternative energy sources for several reasons. So, motivations of using AER can be classified as follows:
a) Personal preferences and ethical motivations for using alternative renewable energy sources and appreciation of the environmental and economic benefits represented by; Reducing global warming by reducing greenhouse gas emissions and air pollution, improving public health, providing inexhaustible energy, creating economic development and job opportunities in manufacturing, installation, considering semi-stable energy prices, availability and flexibility due to diversifying energy supplies and reducing dependence on imported fuel.
b) Resentment of paying for energy services periodically and the desire to reduce expenses due to the low economic conditions, especially in low-income housing areas.
c) Some designers may consider applying alternative energy technology to promote the project architecturally, attract community attention to this project and increase adaptation to climate conditions.
d) In some simple areas, reliance on AER may be compulsory rather than voluntary due to a lack of connection to the national electricity grid (off-grid regions) which is often be in remote areas.

But the key question arises; is it possible to rely entirely on alternative energy? Is it still enough to run all the works of energy sources within the housing units?
Many research and experiences have discussed the difficulty of providing a house with 100% self-sufficiency in alternative energy sources. There is also no single alternative energy system can be used in a modern house that meets all energy purposes, but it must combine more than one [15]. For example, solar heaters can be used to heat water while relying on wind turbines to generate electricity or solar cells for the purposes of lighting, thermal energy for heating, as well as the exploitation of bio-diesel fuel for cooking purposes. Therefore, the decision on the application of alternative energy technologies shall be taken on the stages of permutations and combinations as it requires effort and a relatively high cost of processing.

2.4 Determinants of Using AER.

The determinants for the application of alternative energy sources include several points as follows:

A- Site location options. The options and possibilities of the place in terms of governing regulations and laws, as well as the availability of alternative energy sources, including the proportion of appropriate solar brightness, regular speed winds, water source, the presence of bio-fuel sources that represent a waste of plants and animals, and so on. Just as society's perception of environmental protection issues is becoming more positive day by day, the local governing regulations must be more acceptable and easier to do so.

B- Dealing with objections. The systems and installations of alternative energy is characterized by being different from what around. While some people see wind turbines as dynamic and optimistic, others see them as bothersome and useless. In addition, the many questions that come to mind, which is usually not to search for an answer and end thinking about them is ultimate solution. For example, some wonder how much noise a turbine makes, or does a water turbine pollute water? Will the geothermal system make adjustments to the earth? Will the biogas-based system be clean and safe? All these questions constitute determinants that make the easiest solution is to avoid the experience, which constitutes the largest limitation by users. The fact that the location is in urban or rural areas will greatly affect the acceptance of such ideas [15].

C- Difficulty in calculating the amount of energy produced from alternative energy sources. Although there is a lot of information through which to calculate the energy generated by each of the alternative energy production tools such as wind vanes according to the capacity of each unit (kilowatt) as well as solar cells, and the ability to calculate the energy consumed by the housing unit, the process of calculating the energy generated and consumed also remains inaccurate, particularly when relying on variable energy sources according to environmental changes, as well as uneven household consumption among individuals [16]. In a simplified way, you can calculate the household consumption of electrical power at the house by calculating the total household meter readings over twelve months, then calculating consumption (kilowatt

per hour), then dividing the output by 365 to give an average per day, and then dividing the output by 24 to give the average per hour. This can be overcome with many ideas based on the energy storage process.

D- Financial support. The absence of the cost of switching to alternative energy systems is the most powerful determinant in the application, and it is worth noting the great efforts made by the specialist bodies such as the International Renewable Energy Agency, which has supported many projects, especially in developing countries since its establishment as a governmental organization in 2011, as part of its continuous pursuit of sustainable development.

In addition to a few drawbacks that are associated with renewable energy sources, such as the high cost of maintenance and development work, changing climatic conditions that affect most renewable energy sources. In addition to the inability to produce in large quantities because the amount of energy requires large areas to establish a lot of solar panels and wind farms. Finally, AER are not available in all places, as the intensity of solar energy, water and wind is not available in all regions [17].

2.5 Energy conservation and storage

The process of thinking about the use of alternative energy sources requires a comprehensive preparation of many elements, the most important of which is how to conserve and maintain them. This significant energy depletion directed at a given sector makes it imperative to think about Energy Conservation and Storage. The thermal insulation of exterior walls and ceilings is one of the most effective means for storing thermal energy, provided that suitable insulation material is used with high efficiency, as well as the use of initial design and structural solutions that help provide thermal comfort in the summer and winter normally. Here we find that the works of conservation and reduction of energy consumption requires an integrated planning begins with the following and as shown in Figure 16:

- General site selection;
- The shape and orientation of the building;
- Building construction material and systems;
- Good insulation of roofs and walls while applying some architectural ideas such as roof gardens and green facades.
- Use of alternative energy systems;
- Integrate smart architecture with alternative energy systems into a single management and operation system - Smart home energy management system [18].
- Reduce energy consumption by individuals by raising awareness [19].

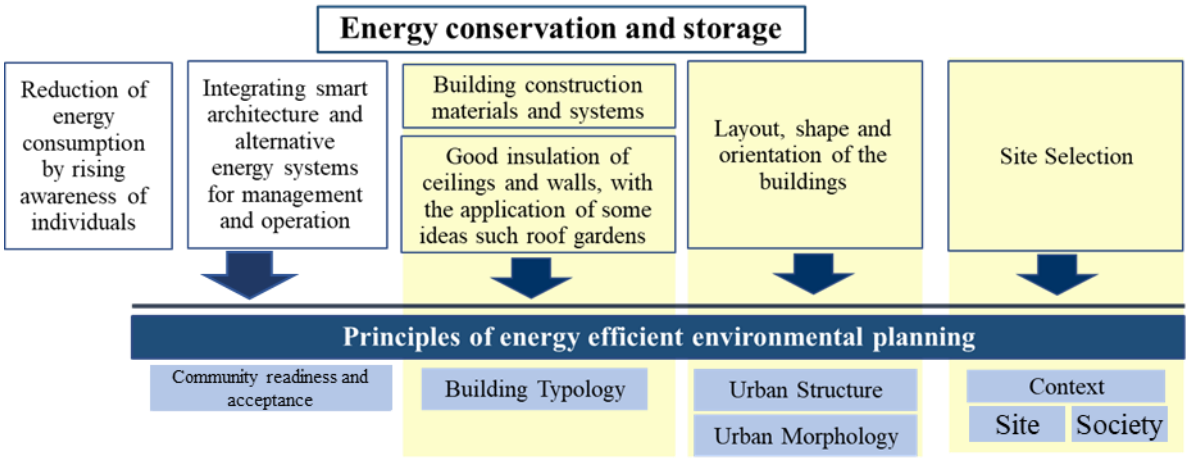


Fig.16. Energy conservation and storage needs (researcher).

Thus, AER application technical requirements can be divided into three sub factors, shown in Table 1. These factors are: a) General site capabilities, b) Implementation equipment like machines and storage batteries and finally, c) Onsite site and buildings' editing.

3. Achievements in the field of renewable energy

One of the benefits to consumers is the competition of producing companies to develop many ideas on generating energy from natural sources, especially in the areas of solar and wind energy at competitive prices. For example, a company announced the possibility of obtaining solar energy through mirrors that condensed the sun's rays and generate electricity and water heating at the same time, consisting of a plate on a simple metal structure. Some scientists in Switzerland have also developed (Solar windows). Its a technology that turns the house glass into solar panels [20], [21], [22], Figure17.

Fig.17. Poly solar opaque series panels (4.6 kWp), Future Business Centre, Cambridge. [20]

Table 1. Technical requirements for implementing alternative energy systems (researcher).

No.	Housing level	Solar Energy	Wind Energy	Bioenergy	Geothermal En.	Water En.
1.1	**General site capabilities**	Good solar brightness ratio	Continuous wind movement rate	-External spaces far from living spaces - No need for direct sun rays or wind	Surrounding land belongs to the project and non-rocky soil to be excavated	Flowing water source in addition to small waterfall or coastal regions
1.2	**Onsite setting**	-The amount of energy produced. - Study the structural loads in case of tanks. -Price according to type	- Establishment permits. - Study the visual effect and noise level. - Construction cost. -Storage batteries cost and place - amount of energy produced	-Taking safety measures, especially when dealing with biogas (potentially explosive) - Finding environmental solutions to get rid of unwanted odors - Providing good ventilation	Calculating amount of energy produced	Fixtures and building safety at the edges of the stream
1.3	**Implementation equipment**	-Ready-made equipment installed over roofs or on a metal skeleton on the ground in case of available space and when a large amount of energy is required -No ground installations are required when used on rooftops -Architectural design modifications include the addition of glass rooms towards sun-facing facades	- wind turbines which vary according to their sizes and their ability to generate electricity -(small turbines can be constructed over roofs)	Digester unit is externally equipped or other pre-casted units	It requires ground installations close to the site, such as drilling, sitting pipes and pumps	Water turbines, electric transformer, generator, and batteries

Applications of produced energy	-Lighting & electricity - Heating water purposes - Passive cooling and air heating	Lighting & electricity	-Car fuel -Cooking and heating purposes - Operating diesel generators needed to run electricity	- Air cooling and heating	- Lighting & electricity
The most common applications	-Solar Cells -Flat and concentrated connectors -Vacuum tubes -Vacuum convection tubes -Passive cooling and heating systems -(solar rooms)	- Small turbines connected to the building - Independent turbines	-Digester \fertilization Unit - The following products can be obtained : Biodiesel, Biogas, Fertilizers	-A loop system mounted on a pond - Closed-loop sys. -Horizontal closed-loop system	using water turbine or natural watersheds and water wheels

The New and Renewable Energy Authority is promoting ideas for alternative energy production, but it is possible to produce energy and sell the surplus of it to the Ministry of Electricity. This has been experimented and implemented so that the energy generated can be connected to the national grid, fully sold or connected to storage batteries. The Central Unit for Sustainable Cities and Renewable Energy in the New Urban Communities Authority (NUCA) affiliated with the Ministry of Housing is also carrying out many successful experiments for solar plants on top of public buildings in cities and preparing incentives for those wishing to construct personal plants [23]. Among the proposed projects in the New Administrative Capital is the Art City project, in which the use of solar panels, wind turbines, and heating pipes was combined with the roof covered with movable solar panels to create shades and generate electricity in the building. With the work of planted walls and ceilings that reduce the total heat of the buildings and contribute to the water recycling process, with the use of smart architecture systems within the residential units ,as shown in Figure 18.

Fig.18. Art City (a new environmentally friendly residential complex) - designed by Belgian architect Vincent Callebaut - Egypt

4. Classification of Residential Areas in Egypt

Residential areas can be classified according to several factors, such as population density, house type and housing region. The most comprehensive classification, however, is based on housing levels, which are determined by a set of social and economic factors, including the area per capita of the residential unit, the number of spaces within the unit, the level of exterior and interior finishing, and the location of the unit within the city [24]. Thus, residential areas are classified into Economy level - intermediate - average and premium level as shown in Table 2.

Table 2. Housing level classification in Egypt.

No.	Housing level	Housing level features
2.1	Economy level	It mostly includes government housing with areas ranging from 50-65 square meters with an economical finishing level. It is also found in slum areas.
2.2	Intermediate housing level	Higher level than before. It is also found in government housing and in informal settlement areas. Its area ranges from 75-90 square meters with a medium level of finishing.
2.3	average housing level	Higher level than before. The private sector often builds them for ownership. It is located in multiple areas in the city center, main streets, and extensions. Most of them are official housing. Their area ranges from 90-120 square meters with a high level of finishing.
2.4	premium housing	Higher level than before. The private sector often builds them for ownership. They are available in the form of residential units in multi-story buildings, or single-family or extended-family villas. Its large area ranges from 160-200 square meters or more, with a luxurious finishing level. It is located in distinguished areas

The entities that provide and finance housing in Egypt are also considered one of the most important determinants governing housing levels. These bodies are represented in the following Table 3 [24]:

Table 3. Entities providing and financing housing projects in Egypt.

No.	Housing financing entities	Identifiers
3.1	Individuals	Those who, through their efforts, provide housing for themselves or others.
3.2	Cooperative societies	which aim to provide housing for their members through the provision of land and loans (from the General Authority For construction and housing cooperatives or the Housing and Development Bank)
3.3	Government entities	The government, localities, and governorates.
		New Urban Communities authority (NUCA) (subordinate to the Ministry of Housing, Utilities, and Urban Communities) funded by the State budget, cooperatives, the Housing and Development Bank, or other entities.
		Housing and Development Bank.
3.4	Business or private sectors	Housing and Development Companies .
3.5	Institutional bodies	such as industrial zones and higher education facilities, which provide housing for their workers and employees.
3.6	Real estate companies.	Private-sector real estate investment companies.

5. Sense of Community in Residential Neighbourhoods

The sense of community is one of the most important aspects of a neighbourhood. It is associated with the dedication given by the community members to one another and society, which bears significance on the sense of security and belonging and leads to satisfaction with and commitment to the community. It is measured as the identification of the community members' feelings about each other and the community's successful functioning [26].

Four dimensions were adopted to measure the sense of community shown in Table 4. They are *(a) membership*: involving boundaries, emotional safety, a right to belong, personal investment and a common symbol system; *(b) influence*: which has to do with group conformity; (*c) integration and fulfilment of needs*: concerned with the importance of community relations that is perceived to be the motivation to create and maintain a continuous feeling of esprit de corps and *(d) shared emotional connections refer to interaction*, shared events, and tied into the psychological aspects of sense of community, as opposed to other affective notions [27].

Table 4. Dimensions for measuring the sense of community.

No.	Housing level	Housing level features
4.1	Membership	It mostly includes government housing with areas ranging from 50-65 square meters with an economical finishing level. It is also found in slum areas.
4.2	Influence	Higher level than before. It is also found in government housing and in informal settlement areas. Its area ranges from 75-90 square meters with a medium level of finishing.
4.3	Integration and fulfillment of needs	Higher level than before. The private sector often builds them for ownership. It is located in multiple areas in the city center, main streets, and extensions. Most of them are official housing. Their area ranges from 90-120 square meters with a high level of finishing.
4.4	shared emotional connections	Higher level than before. The private sector often builds them for ownership. They are available in the form of residential units in multi-story buildings, or single-family or extended-family villas. Its large area ranges from 160-200 square meters or more, with a luxurious finishing level. It is located in distinguished areas

6. Methodology

This research is divided into three parts as shown in Figure 19. *The first one* follows the descriptive method. It includes a literature review about alternative energy resources applying motivations, limitations, and systems principles. As well as classification of residential areas in Egypt and their sense of community. *The second part* follows the inductive method and a baseline survey, where, through the theoretical study, four factors and seventeen (17) subfactors have been recognized to identify characteristics of residential areas appropriate for AER. The main factors include a) Technical requirements, b) type of residential area according to housing type, c) entities of providing and financing, d) sense of community. These factors have been ranked to help decision makers recognize the applicable residential areas for AER. *The third part* includes suggestion for some regions in Egypt suitable for applying AER. The characteristics of these areas were observed by monitoring the spatial potential of the site and housing types, in addition to the sense of communities and based on the determinants studied in the literature review.

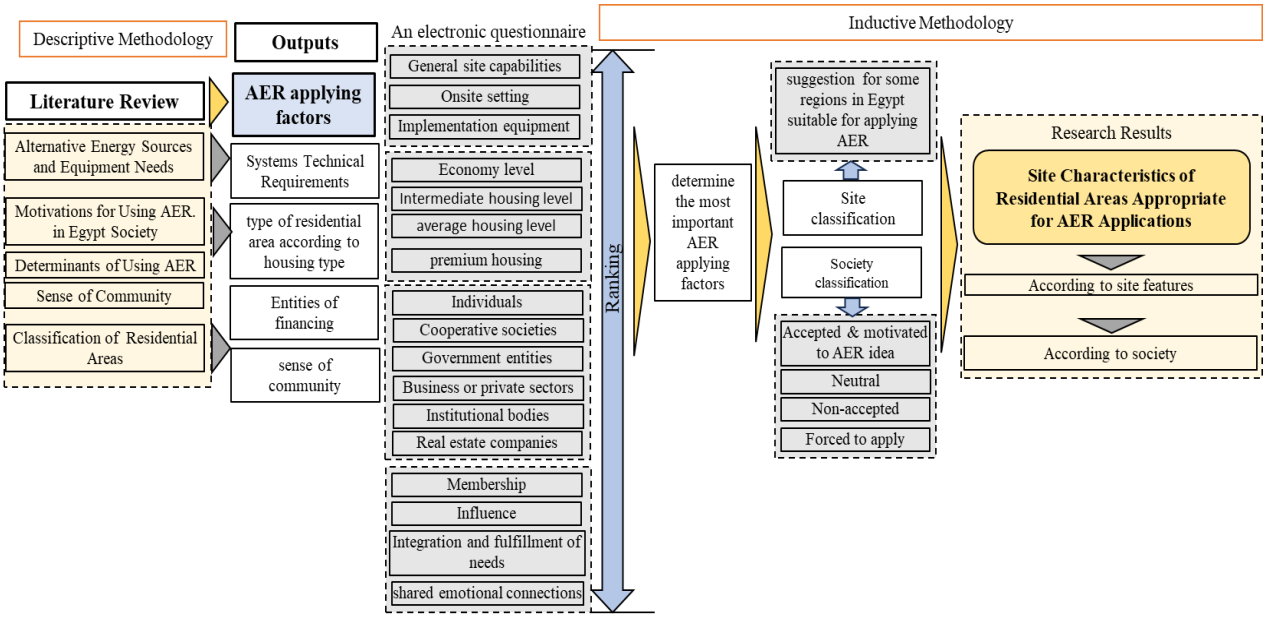


Fig.19. The Main Research Methodology.

An electronic questionnaire was conducted to determine the most important type of AER applying factors (site, building, and structure), then, the most important considerations that affect in designing safe fixed security points in Sinai to mitigate the threat of terrorists and reduce the effect of potential risks. Multidisciplinary stakeholders (25 experts) involved in making a key decision in this issue was selected, then 25 electronic questionnaires were distributed among Architects and urban designers.

Subsequently, the result of the electronic questionnaire was implicated. Statistical analysis was calculated, starting from calculating the mean value (μ), Standard Deviation (α), and the Coefficient of Variance (CV) to measure the homogeneity of the sample, then, concluding the relative importance index (RII) by using (Likert) classification (k) as (EI) = (Extremely important- (I) = important - (A) = Average- (NI) = Not important - (ENI) = Extremely not important, finally, the study set the importance level and relative ranking for each design consideration and role ratio to each phase, as well the global ranking ratio to (45) considerations by using the following equations:

$(\mu) = n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5$ / Total number of samples

(CV) = (α / μ) *100

As regards the (CV) result, the average was 12.92 (between 10-20), which means that sample was homogeneous and balanced where:

CV< 10 = Excellent sample

CV (between 10-20) = Very good

CV (between 20-30) = Acceptable

CV (between 30-40) = Low

CV> 40 = Unacceptable

(RII) = $n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5 / 5(n_1 + n_2 + n_3 + n_4 + n_5)$ [22]

RII = 0: 0.20 = Importance level (Low = L)

RII = 0.21: 0.40 = Importance level (Medium low = M-L)

RII = 0.41: 0.60 = Importance level (Medium = M)

RII = 0.61: 0.80 = Importance level (Medium high = M-H)

RII = 0.81: 1.00 = Importance level (High = H)

Where (n5) the number of experts scored (EI), (n4) the number of experts scored (I), (n3) the number of experts scored (A), (n2) the number of experts scored (NI), and (n) the number of experts scored (ENI).

7. Results

The results of the study were divided into two sections. *The first* is related to the electronic questionnaire throughout the experts' overall evaluation for the AER applying factors, and *the second* section is related to the inductive study as illustrated below.

First, from the statistical analysis of the Electronic Questionnaire, and after verification of the questionnaire through (CV) coefficient as shown in Table 5, Table 6, the most important AER applying factors was the technical requirements, followed by financing entities, residential area housing type, and finally sense of community came at last. The most important sub factor (the highest global weight) was (General site capabilities) too, followed by (Implementation equipment) that reflects the importance of site characteristics compared with other factors. As well as *(eight)* sub-factors were ranked (high), and *(nine)* sub-factors were ranked (high-medium). More specifically, the analysis result determined the most important sub-factors which ranked (high) from *(1) to (5)* ratio to the global rank according to multidisciplinary stakeholders (25 experts) evaluation as:

- *(Top Three) sub-factors* were from the Technical Requirements where, General site capabilities was ranked (1), Implementation equipment were ranked (2), Onsite setting was ranked (3) .
- *(One) sub-factor* wes from type of residential area according to housing type where, average housing level was ranked (4) as the most appropriate housing level.
- *(One) sub-factors* was from entities of providing and financing where, real estate companies was ranked (5) as a preferable financing agency.

Table 5. The statistical analysis of the AER applying factors.

Code/N		EI	I	A	NI	ENI	Mean	Standard Deviation	Coefficient of Variance	Relative Important Index	Importance level	Relative ranking
							μ	α	cv	RII		
AER applying factors	1	22	3	0	0	0	4.880	0.210	4.298	0.976	High	1
	2	15	8	2	0	0	4.520	0.413	9.140	0.904	High	3
	3	16	8	1	0	0	4.600	0.365	7.938	0.920	High	2
	4	15	6	2	2	0	4.360	0.602	13.812	0.872	High	4

1) technical requirements, 2) housing level, 3)entities of providing and financing, 4) sense of community

Table 6. The statistical analysis of the Electronic Questionnaire result

Code/N		EI	I	A	NI	ENI	Mean	Standard Deviation	Coefficient of Variance	Relative Important Index	IL.	Relative ranking	Global rank
							μ	α	Cv	RII			
Tech. Req.	1.1	22	3	0	0	0	4.880	0.210	4.298	0.976	H	1	1
	1.2	18	3	2	1	0	4.583	0.514	11.208	0.917	H	3	3
	1.3	20	4	0	2	0	4.615	0.550	11.918	0.923	H	2	2
Housing level	2.1	12	5	3	1	4	3.800	0.949	24.965	0.760	MH	4	12
	2.2	9	8	3	4	0	3.917	0.681	17.390	0.783	MH	3	10
	2.3	20	2	3	0	0	4.680	0.437	9.330	0.936	H	1	4
	2.4	20	3	2	3	0	4.429	0.694	15.660	0.886	H	2	7
Housing financing entities	3.1	14	9	1	1	0	4.440	0.486	10.941	0.888	H	2	6
	3.2	5	8	10	2	0	3.640	0.574	15.766	0.728	MH	5	13
	3.3	2	14	7	2	0	3.640	0.479	13.156	0.728	MH	5	13
	3.4	7	12	6	0	0	4.040	0.465	11.504	0.808	H	3	8
	3.5	6	13	6	0	0	4.000	0.447	11.180	0.800	MH	4	9
	3.6	16	8	0	1	0	4.560	0.450	9.872	0.912	H	1	5
Sense of commnit	4.1	5	8	11	1	0	3.680	0.539	14.650	0.736	MH	2	15
	4.2	4	8	11	1	0	3.625	0.510	14.078	0.725	MH	3	16
	4.3	5	15	5	0	0	4.000	0.408	10.206	0.800	MH	1	11
	4.4	4	8	10	1	1	3.542	0.605	17.081	0.708	MH	4	17
The average of (Coefficient of Variance)									**12.92**				

Where (EI) = Extremely important- (I) = important- (A) = Average- (NI) = Not important - (ENI) = Extremely not important

(IL) Importance level :(H)=High – (MH)= Medium High – (M)= Medium – (L)= Low

Second, from the study of AER and their application needs, there are some residential areas where the application of the needs of these alternative systems is appropriate, while they are difficult to apply in other areas mainly due to absence of natural site capabilities, since there are sets of factors should be revised.
According to AER determinants, the option of using alternative energy is limited to four categories of users: Accepted & motivated to AER idea, Neutral, Non-accepted, forced to apply. **The first type** includes those who are interested in natural resources and the provision of energy sources that are running out or reducing their consumption. **The second type** is expected to be interested in saving energy wherever it is sourced. In this case, their focus is on the necessary costs and modifications, as they do not care about other details. Non-accepted categories of users is difficult to convince them because of their skepticism about the stability and continuity of energy supply services and their unwillingness to make any adjustments. Users in the **last category**-off-grid communities- who are unable to obtain conventional energy sources and are therefore forced to explore other sources. Some project designers and executives may also be interested in this approach to draw the community's attention to the project and achieve certification from institutions interested in the environment and energy, and thus achieve economic profits.

8. Discussion

Regarding the evaluation of the electronic questionnaire, all of the four main factors to apply AER are in (importance level) where the Relative Important Index (RII) values are close to each other. Logically, Technical Requirements has the highest RII because it's the main domain that includes the general site capabilities. The sense of community came at last, and the reason may be due to the experts' opinion regarding the ability of residents in Egypt to adapt to the available sources of services. Regarding the order of significance of each sub-factor in its group, the most prominent features of AER site and social characteristics can be defined as following: sites with general site capabilities, average housing level, financing projects by real estate companies within a society characterized by integration and fulfillment of needs.
The relation between implementing renewable energy sources and economic costs most likely caused the economy housing level to rank last. However, specialists pointed out, through questionnaire observations, the importance of determining the level of implementation (is it at the level of the residential unit or the neighborhood) so that the relationship between (the level of housing) and (the financing resources) is determined correctly, including determining the number of expenses individually. Experts' opinion have proven that the ability of individuals to recognize their energy demands and to integrate into society is one of the most important traits of successful societies- ranked eleventh in global rank-that can adopt alternate energy sources. Therefore, societies that are close intellectually and economically find it easier to implement.

Based on, literature review and previous questionnaire results, the research suggests general specifications for some regions in Egypt suitable for applying AER. These suggestions have one of the following characteristics:
- A simple remote area; where occupants may reunite to provide the needs of alternative energy systems to be implemented in a central area at a level commensurate with the size of the residential community to serve all houses and adjacent simple service buildings. This applies to many rural areas where most alternative energy sources, including water, may be available as shown in Figure 20. Consequently, calls must be made to transform villages in the governorates into eco-friendly villages so that the State bears part of the equipment expenses and individuals bear the other part, for example.

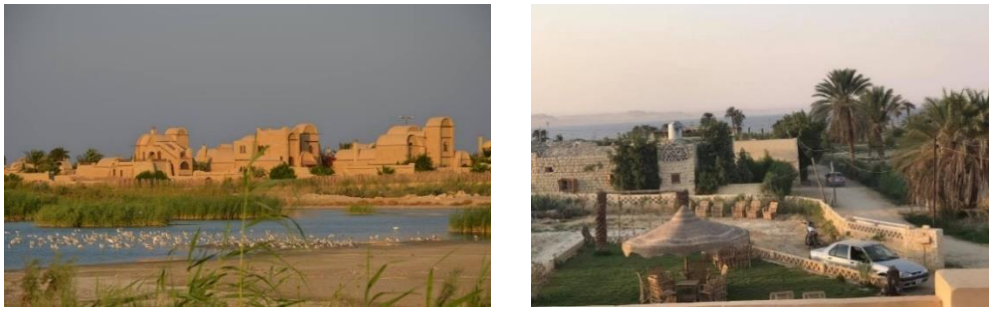


Fig.20. Tunis Village in Fayoum

Competent bodies such as the International Renewable Energy Agency contribute to setting up many projects in developing countries with the aim of reducing carbon emissions, saving costs resulting from reducing fuel imports, serving people, providing jobs and operating many facilities [23].

- Compounds in one of the new communities as shown in Figure 21. Here, it is difficult to apply them at the individual level due to the different cultural thought and personal concerns of energy alternatives, in addition to the fact that they require an area of land around the housing land the possession of which cannot easily be provided by the owner, as well as the permits for the construction of wind towers for an example.

Fig.21. Stone Residence - New Cairo - Zizinia El Mostakbal - Mostakbal City - Fifth Settlement

However, this view differs in some areas where land is delivered so that the building is made on a certain ratio of it and the rest of the land is used either for agriculture or livestock production. These specifications apply to areas such as in Orabi area, Obour city, of Ahmed Orabi Agricultural Cooperative Association for Land Reclamation, Reconstruction and Development, Figure 22 where land areas ranging from 2000 square meters to 8 acres, with a construction ratio not exceeding 60% of the land allocated for buildings, and 10-13% for agricultural plots. There are also many alternative energy sources, especially bioenergy and geothermal energy, as well as the sun and wind energy.

Fig.22. Aerial photo of the land division of Ahmed Orabi Agricultural Cooperative Society for Land Reclamation, Reconstruction and Development

9. Conclusion

The use of AER in architecture is not a modern idea nor an approach to an architectural movement that has emerged with the emergence of energy problems in communities, but rather a design approach whose origins extend to the beginnings of ancient civilizations since the advent of the principles of land developed by human with adapting to the environment data. Therefore, it is necessary to refer to this approach in all aspects of design, beginning from site selection and proper building orientation, selection of suitable construction material, and mastering the appropriate insulation works for roofs, walls and openings so that the alternative sources of energy can be successfully optimized, saved and stored, and all elements contribute in reducing energy consumption and conserving the environment and the proper use of its resources. Through the research, four factors have been recognized to identify characteristics of residential areas appropriate for AER. These factors include the type of residential area according to housing type, entities of financing, type of AER according to main site natural capabilities and to implementation needs and finally the sense of community. These factors and their subfactors have been ranked to specify the characteristics of residential area appropriate for AER which can be defined as following : sites with general

site capabilities, average housing level, financing projects by real estate companies within a society characterized by integration and fulfillment of needs.

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