Orientation in Urban Planning & its Relation with Electric Power Consumption Case Study: Yassin Khuraibet Town

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Abstract. Iraq has suffered since decades from the shortage of supplying electric power to supply residential buildings. This research aims to study the orientation factor in the urban planning and its relation with the decrease of electric power consumption by reducing the cooling loads in summer season, which it is a long season in Iraq. Research tackles problem decreasing in supplying electric power and the disability of government in providing sufficient electric power to the citizens. The research discusses the possibility of decrease of electric power consumption through the study of the orientation factor in the urban planning of a town sector of 4869 residential buildings. Therefore, the research suggests the possibility of calculation of the cooling loads and electric power consumption of a residential building located on an area of 200m². The ground floor is 150m² and the first floor is 100m². This residential building has been entered into e-Quest program at thermal conditions similar to the weather conditions of Basra province and the results show that the best orientation in decreasing the annual electric consumption are the north and south directions.

Research hypothesis the possibility of rotation all residential buildings of Yassin Khuraibet town to the north and south, and these directions are depended according to practical study as above.

Research methodology Yassin Khuraibet is a case study. There is an attempt to re-design the city with preserving the number of the residential buildings, parks and services of this town and to study the effect of residential building orientation to the north and south that are the best directions of electric power consumption for cooling purposes.

Research results appear after it is oriented all residential buildings to the north and south, the town is acceptable in terms of urban planning. The result of calculation shows the decrease of cooling loads 8% and electric power consumption 11%.

1. Introduction

The increase of air conditions, which discharge the hot air, in a residential building because of long hot summer. It has a great effect in the increase of the external atmosphere temperature, but if the residential buildings keep their cooling in summer then the use of air conditions will reduce. Therefore, the external atmosphere is preserved and the environment and economy are balanced in a country such Iraq that has suffered since decades from the shortage of supplying electric power to its residential buildings. The planning of housing area in hot zone like Basra without consideration the orientation in urban planning leads to the increase of electric power consumption as shown in later results. There are
4869 residential buildings in the case study (Yassin Khruaibet), 43 units to the north and 44 units to the south as shown in Table 2 while the rest units are in directions that consume high electric power.

The authorities who is responsible to plan the town should put in their consideration the best orientation for towns is the north and south which may reduce electric power consumption as shown in the practical study. Electric power is one of main keys of civilized societies. The industrial and technical developments in the world increase the need of electric power and this raises cost of electricity power. [1]

Thus, the research tries to treat saving electric power which is one of important subjects. The traditional energy resources become dangerous to the man kind, as well as, they are limit and old. The environmental concept of design contributes to the regional and international efforts to limit the negative impacts resulting from the use of traditional energy resources like the rise of CO2 emissions, climatic changes and depletion of ozone layer which earth experiences. The problem is not local, but it is international. It needs a great effort to face the danger in the future. [2]

The humans use approximately half of electric power inside buildings, and this clarifies that the huge amount of power can be saved if the designs contribute in reducing the costs of cooling, heating and lighting in buildings are adopted [2].

The consumption of thermal energy in buildings has grown very much in the last few years due to the increasing requests for comfort conditions and the related buildings such as residential buildings, offices, hotels, commercial buildings and industrial plants...etc. need more cooling systems [3]. Many purposes are advanced to support more sustainable buildings such as rise of energy consumption, air pollution, fuel price and CO2 emissions that cause the global warming in the environment [4].

Due to the limit of using energy resources in the present time, buildings should be adaptable to climatic changes on daily and townly orbiters [5]. This needs to use natural energies and less harm materials which are known as ecology orientation. These environmentally friendly buildings effect in local or international architectural environment [1].

Many factors are contributed in energy consumption of buildings like ambient temperature, building material characteristics and the performance of appliances such as lighting, heating, ventilating and air conditioning system....etc. [6]. Ambient temperature is one of the important effective parameters on buildings due to it associated with the operation of cooling – heating system and corresponding with the building cooling-heating energy consumption [6]. The studies presented that the building peak electric energy consumption load to increase from total electricity consumption is approximated 4.6% when the temperature rise of one degree and the equivalent 8.5% [7].

The important requirement of environmentally friendly buildings is the optimal use of non-re new energy during the stages of building life. These buildings depend on the operation systems to reduce the use of effective systems in operating a building according to the local climate for the balance between energy and materials and finding more efficient solutions[8]. The building is a reaction of human to external environmental forces to provide a constant internal environment, which needs less energy or effort for thermal comfort. The control of solar radiation in the same building provides the lowest energy waste while maintaining the stability of requiring internal environment [9].

Therefore, architectural designers tried to reach many design solutions to decrease energy consumption in buildings. For example, most buildings use a small windows in the design to reduce the heat but it is not effective method to supply the need of sunlight to the space users ,providing suitable building design like building envelope, story height, building materials and plan shape......etc.[10].

In addition, it is observed that more than 70% of Basra residential buildings need suitable thermal insulation and architectural solutions that can decrease cooling energy consumption in devices. In Basra city (as a special region has of hot climate in summer) ,it has highly hot climate from high temperature, high humidity with a large amount of cooling loads demand in buildings is increased overmuch to reach comfort level [11].

The research aims to study the thermal load of a residential building, to discover the effect of orientation for a residential building and to study the orientation in urban planning while preserving the urban planning norms. The challenges of research are the rotation of residential buildings to north and south while maintaining the acceptance of planning visually.
2. Literature Reviews

Diaa R.M [12] talks about the sustainable planning which is not a complicated design of planning or requires a high cost and technology. It is a normal planning which provides a comfortable internal environment for the user through social norms of residents and environmental features of the location. He thinks that there is a neglect of environmental effects in residential areas, and there is a real problem in the huge energy consumption which needs big economical costs and natural resource. He mentions the efficiency factor of energy and the reduction of cost of its consumption inside a residence while providing the comfort to its users, as a basic principle for the design of sustainable residence in order to provide a healthy living environment and to reduce the negative impact on the environment through a set of design norms: site selection, efficiency of building envelop, efficiency of operation systems, the development of local techniques in producing the energy.

He states that how the orientation of a residential building has a great impact on improvement of thermal performance through the reduction of solar radiation effect in summer and its increase in winter. The orientation depends on the paths of solar radiation. While the buildings are the basic elements in an urban unit, the orientation will be determined later after directing the town as a whole. Changing of residential building orientation makes a difference in the amount of solar radiation exposure during day hours, and it does not change the temperature.

Abdul R.A [13] deals with the planning and participating devices in the planning process and the steps to reach the goals of planning process, moreover, the importance of planning course in urban planning success of a town.

He defines the planning as a regular and sequential study to reach the aim in less or high cost. The planning is always a changeable process according to the time and environmental conditions. He has put many solutions for the present problems which affect in the town or may happen in the future.

He says that many of Iraqi cities expose to deteriorate in their urban environments in the absent of the planning process and overrun on the basic designs through the change of land usage. Iraqi city needs to return the institutions that mean in planning process in order to be beautiful and to achieve a healthy urban environment and comfort for its residents and neighborhoods.

Taghreed H.A [14] searches for finding possible methods to limit (Consumption rationing) electric power consumption in the hot and dry areas. The research goal is to activate the part of architect in rationalization of electric power consumption. There are planning ways related to the features of urban fabric and architectural treatment related to building designs which can be used to limit the negative impact of hard climatic elements in hot and dry areas of Iraq and to reach the thermal comfort for residents without depending on industrial coolant.

She also deals with the factor of building direction as one of planning and design factors affected in the building atmosphere. She explains the effect of directing, reflecting and absorbing solar radiation, the degree of reflection and absorption, the speed of the external air currents as well the outside temperature depends on the building direction in hot and dry areas. These thermal parameters show the actual impact of heat gain process of a building through its different façades which differ in thermal acquisition.

She also mentions the planning and design factors affected in building atmosphere: building direction, building design, method of assembling buildings and outcrops and setbacks of building mass.

Sana S.A et.al [15] states the concept of sustainable community and the determination of important associated vocabularies. This study deals with the sustainable residential planning, and draw sustainable norms as social norms, environmental norms, and economical norms, architectural norms in form that supports each other.

This study also addresses the possibility of growing criterion by achieving the sustainability of communities through the flexibility of surveying standard for residential plots and the variety of estate selections according to family requirements. The flexibility of surveying standard is adopted as a main vocabulary for the research, which means the criterion ability to transform into new formulas which manage the residential needs to achieve the variety in residential selections, thus, it describes as an indicator to measure the growing planning criterion in a sustainable planning community.
The researchers are tried many techniques and design strategies that lead to decreased energy consumption by improvement the masonry of buildings in walls, roofs and floor,...etc. There are several factors that can effect on the energy consumption of a buildings or improve energy efficiency in buildings. The study by Dongwei Y et al. [16] showed that the main factors that effecting in buildings energy consumption are divided into: (1) climate characteristics' (2) building characteristics' (3) user characteristics' (4) services and operating systems' (5) occupants’ action and activities' (6) social and economic factors' and (7) indoor environmental quality required. Nowadays, Integration of the phase change materials (PCM) into the walls of building is an important key for reduction of energy consumption.

Müslüm A. et.al [17] studies thermal performance of PCM in the wall and determine the location, thickness and melting temperature of PCM different climatic conditions for three cities of Turkey. It is found optimization monthly PCM melting temperature change from 6 to 34 ºC and PCM layer thickness change from 1 to 20 mm depending on climatic conditions.

Wang X et al. [18] studied compare between wall without PCM and wall composite with PCM. it is reduced the cooling and heating energy demand about 24.32% and 30% respectively and reduction in the inner surface temperature about 45%-74%.

Many studies have treated the growing of solar cell self-consumption in buildings with benefits it on electricity storage. Rania E. et.al [19] studied effect the solar cells on the buildings in the energy consumption', comfort condition (interior temperature, relative humidity and lighting) and emission of CO2 at buildings. It considers the position, orientation and location of cells on the building in the Alexandria, Egypt. The results showed decrease the annual energy consumption about 15% and 40% when the solar cells on the faced and roof of building respectively.

3. Case study
Yassin Khuraibet is a newly planned town by Basra municipality in the 1990s. It located in the central of Basra consisting of 4869 residential buildings, distributed over 8 directions as in Figure 1 that shows the location of town in Basra. The town was chosen for it is overcrowded and to know the current amount of electric power consumption by calculating the consumption for each unit in specific direction according to the scientific study of thermal mechanics.

![Figure 1. Yassin Khuraibet in side Basra city](image)

4. Research methodology
Yassin Khuraibet is the study case as shown in Figure 2, which clears the basic plan for the mentioned town. The researcher attempts to re-design it in a grid layout while preserving the planning level of the town, the number of residential buildings and park and service areas with their rotation to north, parallel to the residential blocks. It was studied the effect of residential building orientation, the north and south which are the best orientation for electric power consumption for cooling purposes.
A sample of residential building was designed by the 1st researcher on building space of 150 m$^2$ ground floor 100 m$^2$ the first floor and on land of 200 m$^2$ has been entered in the e-Quest, accredited program in the field of thermal engineering as shown in Figure 3.

The methodology of this work contains of many main steps, starting with the collection data about the weather of Basra city. The data is inputting on the energy simulation by using e-Quest program to calculate hourly the energy consumption for heating, cooling and electric energy consumption of the base design after define all characteristic of the building show in Table 1.
Table 1. Characteristics of building [20]

| Characteristics       | Description                                                                 |
|-----------------------|-----------------------------------------------------------------------------|
| Plane shape           | Rectangular                                                                |
| Area                  | 200 m²                                                                      |
| Wall exterior color   | White                                                                       |
| External walls        | 5 cm Stone + 5 cm Cement Mortar Outside + 24 cm Ordinary Brick + 0.5 cm Gypsum Plaster Inside |
| Roof                  | 4 cm Tiles Outside + 10 cm Sand + 5 cm Polystyrene + 0.3 cm Asphalt + 17 cm Concrete Slab + 0.5 cm Gypsum Plaster Inside |
| Floor                 | 4 cm tiles + 5 cm cement mortar + 10 cm low weight concrete + 100 cm sand |

The heat balance process calculates thermal loads (cooling and heating) of buildings. This method determines the thermal balance on outdoor and indoor faces and calculates heat conduction during building construction. When the calculations end to one residential buildings, it was calculated the number of houses in the town in each direction as shown in Table 2.

Table 2. The number of houses in Yassin Khuraibet city

| Direction     | Number of houses | Descent   |
|---------------|------------------|-----------|
| North west    | 976              | 20.049%   |
| South West    | 1325             | 27.212%   |
| north East    | 1319             | 27.089%   |
| South east    | 999              | 20.517%   |
| North         | 43               | 0.883%    |
| South         | 44               | 0.903%    |
| West          | 84               | 1.725%    |
| East          | 79               | 1.622%    |
| Total         | 4869             | 100%      |
It was calculated the reality thermal load of the town. Indeed, the site plan for the study case is obtained from Basra municipality, but it was on paper as shown on Figure 4, which shows the reality of the study case. There is no copy made by engineering drawing programs, thus, grid lines was drawn on the site plan paper and the same thing in AutoCAD 2020 program.

Figure 4. The basic plan of Yassin Khuraibet from municipality of Basra city

The coordinates of main town points projected in the computer, the external main streets and internal service area as in Figure 5 which shows the transferred map in the computer after projecting the grid, the service areas are rotated and the residential blocks were put while preserving the urban planning norms.

Figure 5. The boundaries of the town drawn in AutoCAD program Basra city
After drawing of residential blocks, the number of houses has increased to 5097, and thus the houses increased to 236 from the reality of the situation. The results will be confused because the hypothesis based on the same number of residential buildings, so the park areas between the residential blocks were increased, and the number of houses were exactly reduced to 4869. Figure 6 which shows the modified planning of the town due to the calculation of town consumption after the change of direction for the same number as shown in Table 3.

**Table 3.** The number of houses in new design for Yassin Khuraibet city

| Direction | Number of houses | Descent  |
|-----------|-----------------|----------|
| North     | 2447            | 50.256%  |
| South     | 2422            | 49.744%  |
| Total     | 4869            | 100%     |

5. Results and Discussion

5.1 Description of energy consumption

The map of Yassin Khuraibet city show the number of houses in this city increases in directions southeast, southwest, northeast and northwest when compare it with another directions north, south, west and east see Figure 7. This leads to more energy consumption in this directions due to the randomness of urban planning.
Figure 8 shows the cooling energy consumption demand of the city in all direction. It is seen the maximum energy consumption in the southeast direction about 107842.05 MWh and minimum energy consumption in the north direction about 4103.2 MWh. We can understand from figure of cooling energy consumption that the maximum consumption in the directions southeast, southwest, northeast and northwest.

Figure 9 that show heating energy consumption in the city for all direction. It is found the maximum energy consumption in the direction southeast, southwest, northeast and northwest and reach high consumption in southwest and northeast direction about average 4058.6 MWh. It is found the minimum energy consumption still on the directions north, south, west and east. The north direction is the best due to it has minimum energy consumption about 101.91 MWh.
In the electric energy consumption of the same city in all directions is not different from heating or cooling energy consumption. Figure 10 shows the best direction in the electric energy consumption is north direction when compare it with anthers and maximum electric energy consumption in the southeast, southwest, northeast and northwest.

**Figure 9.** The heating energy consumption in Yassin Khuraibet city

As a result of the data for reality of the city appear that the maximum energy consumption for heating, cooling and electric is found in the directions southeast, southwest, northeast and northwest and minimum energy consumption for heating, cooling and electric is found in the directions north, south, west and east. This can be explained by the increase in the number of houses for the area and their concentration in certain directions and their decrease in other directions that cause the variation in the energy consumption of the city, which affects the electric power plants in an attempt to equip the city with sufficient consumption energy. Useful to reach urban design for cities with low consumption.

**Figure 10.** The electric energy consumption in Yassin Khuraibet city
5.2 The urban design of city

After the bad results that obtained from the reality of the city because the large consumption for energy during year. Architects must reconsider urban design and take into account the planning of thermal engineers to achieve optimal design.

In the new design, it is suggested rearrangement the houses in the city withe urban design to reach for decreasing in the energy consumption for cooling, heating and electric all year. In the new design of the city, the houses were rearranged so that they were placed in two directions: in the north direction and the in the south direction, taking into account the design aesthetic as a first goal, and reaching a reduction of energy consumed as a second goal.

Figure 11 show the compare for cooling energy consumption demands between the base and the new design of city. The result show that decreases in energy of cooling consumption in new design from 513406.45MWh to 476322.96MWh. The new design for city saving about 7% from total energy consumption in summer. It is long season in Iraq about seven month and very hot therefore, it need for cooler system for long time to reach the comfort level.

The above result can be explained by the fact that the redesign focused on transforming the new design for the best two directions, the south and the north. Additional they are considered the best trends in energy consumption if compared to other directions while preserving the aesthetic of the city as well as organizing the distribution of homes between these two directions.

Figure 11. The cooling energy consumption in base and optimal design of city

Figure 12 shows the compare for heating energy consumption demands between the base and the new design of city. The result show the optimal design has high heating energy when compare it with base design. If the city remain on the old design, it can saving energy about 0.17%. Depending on this result, two reasons that it is preferred the optimal design than base design .first reason that the heating season shorter than cooling season in Iraq and three months only need for used heating system. Second reason that the saving in heating energy consumption in optimal design very small when compare it with saving in cooling energy consumption.
Figure 12. The heating energy consumption in base and optimal design of city

Figure 13 show the compare for electrical energy consumption demands between the base and the new design of city. It can found optimal design has minimum energy consumption about 628608.06MWh when compare it with base design of city has704517.91MWh. The result show the optimal design is best due to it is saved in energy about 11% from total energy consumption during the year.

Figure 13. The electric energy consumption in base and optimal design of city

6. Conclusions
The study discussed that it is possible to go a long way across improving the thermal performance of a resident buildings by urban design in Yassin Khuraibet city that can be shortened in the many points:

- After the appearance of results, the research shows the best orientation for residential buildings in Basra, which is known of long hot summer, is north and south.
- The whole town can only oriented in two directions to reach the thermal comfort most of the year and to reduce the need of industrial coolant.
- In the new design for city, it is saved the cooling energy consumption demands about 7% in the hot season which it is rise energy consumption when compare it with another seasons.
• Although the heating energy consumption in the new design which increasing about 0.17% from old design but it is preferred the optimal design because the heating consumption of energy in cooling season for short months when compare it with hot months.
• The urban design show saving in the electric energy consumption for new design about 11% for a long year. It is a good result to reduce the suffering of continuous power outages if applied to future urban plans.
• The research shows the best orientation for residential buildings in Basra, which is known of long hot summer, is north and south.
• The whole town can only oriented in two directions to reach the thermal comfort most of the year and to reduce the need of industrial coolant.
• The urban planning is acceptable in two directions only.
• The research, through its results, can make the orientation an essential element that should consider in putting the basic plan for any urban area according to its thermal conditions.
• The increase of the production of electric power, in addition to what mentioned in the above point, leads to the increase of air pollution, the chimneys blow huge amount of CO$_2$ as a result of combustion processes to produce energy.
• The research does not mention that the beauty of variety in orientation of the basic plan makes the town with distinct features, but that consumes a lot of electric energy.
• The design of wonderful house according to the desire of its owner with wrong direction makes the house unhealthy and always needs air conditions.
• House directing is not one of things that a citizen can obtain. Therefore, the relevant authorities must observe the direction, another factor appears which the increase in electricity costs is for this citizen.
• The rotation to the north and south, as stated in the results, leads to the increase of residential buildings, and if there is a need for more residential buildings, there is a solution as mentioned in the results.

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