Grid Electricity Demand Reduction through Applying Active Strategies in Baghdad-Iraq

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Abstract: This paper is investigating the electricity demand reduction due to the use of active strategies for typical house in Baghdad. The motive was to reduce depending of the national electricity grid which is not reliable and suffers frequent daily interruptions. Simulation methodology was used to carry out this study using IES-VE software to model the energy consumption, calculate, and evaluate the power consumption and energy saving. The study covered the following parameters: coefficient performance of air-conditioning systems, solar domestic hot water, and photovoltaic panels.

The study covered different scenarios to arrive at the optimize case for each parameters in order to highlighted their effect on the energy saving, the result collected from all the simulations were categorized according to each parameter. The result indicates potential energy saving up to 39.1% for the optimized configurations.

Keywords, Active strategies, energy saving, IES simulation

1. Introduction

A great interest has been growing among engineers and architects to design and create intelligent buildings. According to Ochoa and Capeluto [1] the active strategies are the active features or elements which are designed or added to the building to be self-adjusted to changes initiated by their internal or external environment. These strategies enhance the design of the building to achieve the thermal comfort conditions while reducing energy consumption. Silva et al [2] noted that ”intelligent building” has become important infrastructures to minimize the operation cost of the building and provide comfort and safety for the occupant. Al Naser [3] found that the (GCC) countries have enormous solar power that can reach approximately (500-600 W/m2) for each Km2 of land annually. In other words, this amount of solar energy is equivalent to 1.5 million barrels of crude oil. The integration of the solar DHW with PV and the building structure are the main way for solving the energy problems of the future. Ochoa and Capeluto [1] believed that the combination of active features and optimized passive strategies during designing buildings can achieve a savings of about 50 - 55% for most cases. the passive strategies have been investigated in a pervious research published in SB13 Al Badri & Abu Hijlah [4]. The paper coverd many passive strategies including shading devices and insulation materials through reducing the U-Values of roofs, walls. In addition, the study examines different solar heat gain coefficient (SHGC) of glazing system. The outcome of using passive strategies shows
that the most affected parameter is the roof insulation while the second effect factor is wall insulation. The results of adopting a glazing system could vary from one project to another in relation to the ratio of openings to walls. However, it was found that by using shading devices, the impact on energy consumption was the minimum. Overall, the passive strategies combined can achieve 8.3% energy demand reduction. The study focuses on the solar energy in two types of implementation: Coefficient of performance COP of the airconditioning system, Solar Domestic Water Heat SDWH, and Photovoltaic Panels (PV).

2. PARAMETRIC STUDY
According to International- Agency [5] information and analysis Unit (IAU) reported in July 2010 for UN that households were receiving just eight hours of electricity per day in 2007. The United Nations Development Program (UNDP)[6] noted that the electricity supply has been deteriorated in some area especially Baghdad. According to Ministry of Electricity, Iraq is generating 8,000 megawatts only while the currently required power is rising to 13-15,000 megawatts. Since 2003 the public approval of the electricity demand has never records over 39% even during low demand periods[5]. Observations done by the author in July 2012 associated with the facts that have been mentioned above create the outline of the problems which are highlighted as follows:
- Electrical power disconnects for several hours daily
- Private electricity generators are located between the residential zones and operated by unprofessional labourers as shown in Figure 1
- Electricity connection cables have been added randomly without any level of safety and secure, although, many families depend on these private generators, the amount of providing energy is very limited and it could not cover the actual demand of each house
- Almost every house should apply a converter to switch from the grid electricity to the private generators. This device could be damaged continuously and should be replaced by another one which cost money and effort.
Many Iraqi families could not apply the electricity for their houses because of the lower income.

Figure1. Private electricity generator in the middle of the residential area which runs by unprofessional Labourers in (Baghdad July 2012 taken by author)
Figure2. Electricity connection cables have been added randomly without safety and security (Baghdad, July 2012 taken by author)
A typical house located in a popular area in Baghdad was selected to serve as a base case for this research. The selected house was two stories high with a land plot area of 780 m$^2$. Table 1 includes the highlights of the selected house. The house was modeled using ModelIT which is the model building component of the IntegrationEnvironment Solutions - Virtual Environment (IES-VE) modeling software. The ModelIt allows the user to create 3D models required by other components and enable appropriate levels of complexity to be incorporated within a model across the entire design.

Table 1: Case study descriptions (typical house in Iraq/Baghdad)

<table>
<thead>
<tr>
<th>Item</th>
<th>Ground floor</th>
<th>1st floor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor area (m$^2$)</td>
<td>259.7</td>
<td>166.8</td>
</tr>
<tr>
<td>Total enclosed volume (m$^3$)</td>
<td>779.2</td>
<td>500.5</td>
</tr>
<tr>
<td>Outside wall area (m$^2$)</td>
<td>240.6</td>
<td>178.1</td>
</tr>
<tr>
<td>Glazing area (m$^2$)</td>
<td>35</td>
<td>16.1</td>
</tr>
<tr>
<td>Window/wall ratio (%)</td>
<td>14.5%</td>
<td>8.9%</td>
</tr>
</tbody>
</table>

The IES – VE software offers the ability of creating different type of profiles for the same project. It is usually used to scheduled occupancy, HVAC system, and lighting, equipment, used according to the variation over a year. The operation profile of this study is based on the typical lifestyle of an Iraqi family. Three types of profiles have been setup which are; daily profile, weekly profile, and annual profile to provide accurate input data to obtained results with high level of validity. The daily profile assumes that from 8 am to 2 pm people will be out for work and education. Consciously the occupancy and the used of HVAC will be zero while it will be 1 unit when people will be back. (1 means 100% used in the software consideration) As well as the use of HVAC is linked to the occupancy profile. Meanwhile, weekend days have been assumed as full day occupancy and used (Iraqi families usually spend the weekend mainly at home). Thus it assumes the occupancy profile and HVAC system will be on continuously during the weekend days (Friday and Saturday). The annually profile is a frequently repetition of the weekly profiles, as exceptions it has adopted two types of profiles, for summer and winter. All these profiles have been considered for each simulation to increasing the reliability of the results. The IES-VE software provides the ability of creating different layers of constructions and finish materials according to the scenario of the simulation.

3. SIMULATION RESULTS

3.1 Coefficient of Performance (COP) of Air Conditioning System

This scenario addresses the impact of chiller efficiency on total energy demand reduction through using another type of air-conditioning system. Many countries still neglect the significant importance of this strategy in order to achieve energy savings very easily within a limited time. According to the ASHRAE/IES Standard 90.1 [7] the efficiency of air conditioning systems have improved over the years in order to reduce energy consumption. The Coefficient of Performance (COP) of split units has improved from 1.7 in (1977-1997) to be 3.8 in 2006. This scenario increased the COP from 2.5 to 3.5 to examine the impact of the
air conditioning efficiency on energy demand reduction and savings. The results of this simulations show that the total energy was reduced from 139.6 MWh to be 127.8 MWh representing approximately 8.5% in reductions.

3.2 Solar Domestic Water Hot (SDWH)

According to solarelectricityhandbook.com [8] the most suitable angle of the sun in Baghdad, especially in coldest month such as January, is 41 percent from vertical. In order to face south, the simulation adopting azimuth angle is 180 clockwise from the north and the solar collector tilted toward 49 per cent from the horizontal as offered through IES-VE simulations. While the area varied as (2, 4, 6, 8 and 10) meters square to select the optimized case that reduced the boiler energy and did not affect the photovoltaic panel production. Regarding the previous results of the annual total energy consumption, boiler energy has the smallest part of the consumption, which means that the results of this scenario will not affect the total energy consumption as expected. The major impact will appear on the boiler load. The results show that the boiler load was been reduced from 0.1163 MWh to be 0.016 MWh. By selecting an area of 4 meter square, this gives enough space for the PV to be installed. Meanwhile, the balance between both strategies will achieve a significant increase in energy production while having a demand reduction. These simulations have been done separately to investigate the proper configuration for each one.

3.3 SunCast analysis

SunCast simulations show the upper roof received about (1845 kWh/m²) of solar radiation yearly. Part of the downstairs roof received the same amount with the exception of the shaded area that gained between (1521 - 1359 kWh/m²), this analysis aims to determine the best location of the PV, the roof specifications, shading profile, and the available area to achieve the highest level of efficiency. This simulation gives evidence that it is important to add the pergola to provide a suitable place for installing the PV and to avoid any shading factors that could reduce the output power of the PV system. The pergola was a part of the passive strategies as mentioned in the introduction, and it also offered shaded area services for the house.

3.4 Optimized Angle of PV Panels
The first simulation of this scenario will adopt 166.8 m² area (second roof only) to be occupied by PV ignoring the first floor roof. This scenario assumed that the first floor roof will be used to apply the outdoor air conditioning system. Solarelectricityhandbook.com [8] provides the optimized monthly tilt angle in Baghdad, Iraq, throughout the year in order to achieve the greatest performance from the system. Five different angles have been selected to examine the most efficient one that could enhance PV production. The selection has been done according to peak radiation and the hottest months: June, July, and August. The other angles selected were in January and March. The angle for January was 49 degrees from the horizontal (90-41) while the azimuth was 180. In order to maximize the opportunity of facing south, consideration is given to the existing orientation of the case study. The simulations of each angle have been highlighted in Table 2 to understand the proper angle for energy production, angle 25° from the horizontal (equal to 65°) was considered suitable for August. The total annual production of PV increased through the changing of the tilt angles from 28.79 MWh to 30.76 MWh.

Table 2. PV production power of different tilted angles

<table>
<thead>
<tr>
<th>Case</th>
<th>Case b</th>
<th>Case c</th>
<th>Case d</th>
<th>Case e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angles from horizontal</td>
<td>49</td>
<td>33</td>
<td>10</td>
<td>17</td>
</tr>
<tr>
<td>Month</td>
<td>January</td>
<td>March</td>
<td>June</td>
<td>July</td>
</tr>
<tr>
<td>Total annual PV productions (MWh)</td>
<td>28.7959</td>
<td>30.5884</td>
<td>29.8057</td>
<td>30.468</td>
</tr>
</tbody>
</table>

### 3.5 Optimized Area of PV Panels

This scenario examines the extended roof as pergola with the shading devices over the windows. The area of the roof, including the extension, is 300 m². The total roof area will be 270 m² to install the PV panels because 10% has been reduced for maintenance. The simulation examines the Monocrystallin Silicon type of PV. The other type of PV cells will be tested in the next section. The results of the simulations show that the PV production was increased from 30.76 MWh to 50 MWh representing 66.6%. Furthermore, the net energy demand was reduced from 127.8 MWh to 77.8 MWh giving a percentage reduction of 39.1%.

### 3.6 Photovoltaic Panels Performance

This scenario will examine the major differences in the types of solar cells between Monocristalline Silicon, Polycrystalline, Amorphous Silicon, and Thin Film. According to Stapleton and Neill [9] the most efficient type is the Monocrystalline because it offers considerable performance when compared with other types of technologies. The utilization of these types varies from one project to another according to the available space, requirements, and preliminary cost. Monocrystalline silicon has been adopted for all previous simulations through IES-VE configurations. Due to the results of this scenario, the most efficient type of PV cells is Monocrystalline if one does not take into consideration the set up costs. Monocrystalline Silicon has the highest production which is 52.64 MWh, Polycrystalline Silicon production is 44.54 MWh, while Thin Film achieve 29.65 MWh and Amorphous Silicon has the minimum production which is 21.91 MWh.

### 4. PV Production and Peak Demand
The occupied daily profile, assumes that people will be out from 8 am until 2 pm. Therefore, the use of energy drops to zero during this time period. On the other hand, the production of PV will peak during the daytime. The selected day is Wednesday, 18 August, which represents a normal workday during the hottest month as shown in figure 5. The graph indicates the gap between the energy producing times and the net electricity demand during the day. In addition, the actual demand has been dropped to zero from 8 am to 2 pm according to the occupancy profile. Meanwhile, the net energy demands are shown as a negative value because the amount of energy production is more than the energy consumption. Figure 6 shows the weekend of Saturday, 14 August. Overall, the energy produced should be stored until the demand time. Two solutions for this problem which are:

1- Stand-alone systems
2- Grid connected systems feed the electricity generated by the PV back to the grid, instead of storing it in a battery

Figure 5. Peak time of PV production and net energy demand due to occupancy (22 of August, week day)

Figure 6. Peak time of PV production and the net energy demand due to occupancy (14 August, weekend)

5. CONCLUSIONS
The results show that the most effective active strategy and can be achieved quickly and easily by choosing an air conditioning system with more Coefficient of Performance (COP). This allows immediate energy reduction if cost issues are compared with energy savings. The research found that adding Solar DHW is not worth comparing with a lack of PV energy
production especially in hot climates. It was found that increasing the installing area of PV increases the PV production from 62.6% to 66.6%. In addition, the additional PV panels on window shading devices achieved 6.3% extra production. PV Panels performance depends on many factors, such as the availability of space, location being to the south, and shading profile. Thus, whenever the installing area for the PV increases, the energy production will be enhanced accordingly. Different types of PV cells were tested in the study to examine the level of performance for each model. The Monocrystalline is the most efficient type of PV cell, which provided the highest rate of energy production at 52.6 MWh. Although the initial cost of Monocrystalline is high, it is justified when compared to the output power. Polycrystalline has a lower price but lower efficiency. Finally, the production time of the PV needs to correspond with the demand time in order to avoid losing energy. The energy should be stored until the demand time, either through using a stand-alone system that utilizes a battery to PV system, or by using a grid-connected system, which feeds the electricity generated back to the grid. Overall, Increasing the Coefficient of Performance of the air-conditioning system could achieve an 8.5% energy reduction, the net energy demand was reduced from 127.8 MWh to 77.8 MWh giving a percentage reduction of 39.1%. The integration of both the passive and active strategies can achieve a 50.6% energy demand reduction. Ultimately, the impact of each strategy will contribute to enhancing energy performance and savings. The study concluded that the integration of passive and active strategies significantly reduces electricity demand.

REFERENCES


[5] Inter-Agency information and analysis (IAU). (July 2010) Electricity in Iraq Factsheet


