FEASIBILITY STUDY FOR GREEN ARCHITECTURE IN TEMPERATE REGIONS (GAZA CASE)

Emad S. Mushtaha ¹, Masamichi Enai ², Hayama Hirofumi ³, Taro Mori ⁴

GRADUATE SCHOOL OF ENGINEERING
HOKKAIDO UNIVERSITY- JAPAN

ABSTRACT
The environmental impact of house design, construction and operation has low priority in studies as compared to the conventional involvements in cost, size, form, location and aesthetics. Gaza’s climatic data indicates that; 45% of the year is cold while 34% is warm, which requires finding a flexible design tool that can satisfy human comfort into a current predominant green architecture concept, which provides efforts to improve the thermal environment and ventilation of buildings through identifying, developing, and testing innovative concepts that have potentialities for diminishing the rapid use of purchased energy in houses. The bioclimatic charts and Mahoney tables are conducted herein; moreover, basic principles of Successive Integration Method have been utilized on some materials and varying passive elements to achieve new buildings strategies and modules. An integrated design with floor cooling and heating, natural ventilation and some additional passive techniques show that both indoor temperature and lower energy consumption are properly maintained.

KEYWORDS
Thermal comfort, design tools, natural ventilation, Successive Integration Method.

1. INTRODUCTION

These days, several housing problems are subject to discussion, one such problem occurs in the Middle East where the highest densely populated areas in the world are located in Gaza’s camps with 100,000 persons/km². Moreover, a study was obtained from 34 housing projects distributed in several locations in Gaza. The results confirm that most housing projects have no organizational form; in addition incomplete buildings are a common phenomenon dwelling place. Achieving healthy housing designs within the least means in a sound environment is more important than the balanced population growth. Hence, Gaza has several severe climatic problems through the year such as heat and humidity in summer, cold in winter and short periods of autumn and spring. Moreover, the monthly mean maximum air temperature is (31.2) °C in a typical summer, and monthly mean minimum air temperature is (6) °C in the winter. The percentage of winter heating is (45) % while in summer cooling is 34%. Nevertheless, the existing environmental concerns for thermal comfort focus on the summer rather than the winter due to the lack of mean annual precipitation (410) mm. Accordingly, this paper aims to achieve passive mobile strategies, which consider the relation of the human, building and climate with low energy usage.

¹Hokkaido University, Japan, Master Degree.
²Hokkaido University, Japan, Professor.
³Hokkaido University, Japan, Associate professor.
⁴Hokkaido University, Japan, Assistant professor.
2. OBJECTIVES

The study aims to achieve:
(a) The most effective and required strategies for environmental design to maximize human comfort.
(b) Convenient concept of green’s design elements within low-energy building.

3. METHODS

The study is particularly specified as follows:
(a) Applying the bioclimatic charts and Mahoney tables to Gaza, which facilitate the analysis of outdoor climatic data with different charts, moreover to infer required design tools to restore human comfort in buildings.
(b) Developing some of the earlier revealed strategies by adopting some calculative equations, in addition to Successive Integration Methods to evaluate the thermal environment of the structure.

3.1 BUILDING BIOCLIMATIC CHARTS & TABLES

Bioclimatic charts analyze climatic elements of a specified area in order to clarify the needed corrective measures to get healthful and livable houses with reference to the thermal comfort zone, which is defined as “the range of climatic conditions within which the majority of persons would not feel thermally discomfort either heat or cold” [3].

3.1.1 Olgyay’s bioclimatic chart

The chart was developed in 1963 to associate the outdoor climate into building design guideline process. The use of the chart is directly applicable only to inhabitants of the temperate zone at elevation not in excess of (1000) feet above sea level with customary indoor clothing, doing sedentary or light work [4]. This chart clarifies the needed corrective measures to achieve the comfortable zones for a human being. In this chart the relative humidity is the abscissa and dry bulb temperature is the ordinate. The comfort zone is fixed around (21-27.8) °C and has small seasonal adaptations in winter and summer.

- Application of Olgyay’s bioclimatic chart to Gaza
  Outdoor conditions have been plotted to Olgyay’s bioclimatic chart as shown in figure (1), which is identifies conditions for each month of the year. They represent the average daily maxima and minima data of both dry bulb temperature and relative humidity. This chart suggests that for summer’s months (June-September) ventilation is an innovative tool to restore comfort. The chart also indicates that for winter’s months
(Dec–March) solar radiation is needed more than (April, May, Oct, Nov) about 850 w/m² to mitigate the outdoor temperature to comfort zone. On the other hand; the chart for months (April, May, October, November) indicates that daytime lies in the comfort zone but at night a space heating is required.

### 3.1.2 Givoni's bioclimatic chart

A study was developed by Givoni 1976 to address the problems associated with Olgyay’s charts discussed previously. Moreover, it is based on the expected indoor temperature of buildings instead of the outdoor temperature and it is graphically drawn on a conventional psychrometric chart. The chart suggests boundaries of climatic conditions within which various building design strategies. Proper passive cooling and heating strategies were achieved by plotting the linear relation between average mean temperature and relative mean humidity.

- **Application of Givoni’s bioclimatic chart to Gaza**
  
  Outdoor conditions have been plotted to Givoni’s bioclimatic chart as shown in figure (2), which clarifies twelve different monthly lines of the year. It has noticed that a thermal gain and an effective measure are needed to restore comfort for the months of (December-March) and for (April and November)’s nights. Moreover, natural ventilation coupled with mechanical ventilation to restore comfort for the months of (June-Sep). Furthermore, (October and May) fall in the comfort zone except a few short periods during the night, which fall outside the comfort zone, when passive heating is required. Therefore, this chart determined the required strategies for achieving the comfort zone.

### 3.1.3 Mahoney tables

Mahoney tables are applied to fit building’s characteristics to the existent climatic conditions. The Department of Development and Tropical Studies of the Architectural Association in London developed theses tables for achieving methodologies for a responsive design. The predicted elements of some constructions are being tabulated to consider the relation between building details and their contact with the surrounding climatic data. Generally, the monthly climatic data are tabulated such as mean temperature maxima and minima, mean relative humidity (maxima and minima), rain and wind. Utilizing these tables and following the processes of each table’s diagnosis, new indicators were concluded in numbers, which in turn, estimated how the building’s elements should be in a region. The processes and steps are as follows:
(a) Climatic data

The climatic data (dry bulb temperature, relative humidity, precipitation and wind) are classified into some groups as follows:

- **Dry bulb temperature**
  
The climatic data represented in monthly mean maximum and minimum air temperature are tabulated in the whole year’s months as in table (1). Annual mean temperature (AMT) is calculated according (AMT= highest+lowest/2) while; Annual mean range (AMR) is calculated according (AMR= highest-lowest). “High” temperature is the highest value of monthly mean maximum temperature while; “low” temperature is the lowest value of monthly mean maximum temperature.

<table>
<thead>
<tr>
<th>Air Temperature (°C)</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
<th>High AMT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly mean max</td>
<td>16.6</td>
<td>17.2</td>
<td>17.7</td>
<td>22.9</td>
<td>23.8</td>
<td>27.5</td>
<td>31.2</td>
<td>30</td>
<td>28.6</td>
<td>25.5</td>
<td>23</td>
<td>18.9</td>
<td>31.8</td>
</tr>
<tr>
<td>Monthly mean min</td>
<td>9.8</td>
<td>10</td>
<td>11.5</td>
<td>15.9</td>
<td>17.8</td>
<td>21.7</td>
<td>26</td>
<td>24.5</td>
<td>22.8</td>
<td>19.1</td>
<td>15.9</td>
<td>12.6</td>
<td>9.8</td>
</tr>
<tr>
<td>Monthly mean range</td>
<td>6.8</td>
<td>7.2</td>
<td>6.2</td>
<td>7</td>
<td>6</td>
<td>5.8</td>
<td>5.5</td>
<td>5.8</td>
<td>6.4</td>
<td>7.1</td>
<td>6.3</td>
<td>Low AMR</td>
<td></td>
</tr>
</tbody>
</table>

Table (1) Air temperature

Hence AMT is a value equal more than 20, Then from table (5) the choice is arranged for AMT>20 in table (2) with the classifications of the humidity groups from 1-4 supported by humidity’s percentages.

<table>
<thead>
<tr>
<th>AMT&gt;20</th>
<th>Day (RH)</th>
<th>Night (RH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-30</td>
<td>1</td>
<td>26-34</td>
</tr>
<tr>
<td>30-50</td>
<td>2</td>
<td>25-31</td>
</tr>
<tr>
<td>50-70</td>
<td>3</td>
<td>23-29</td>
</tr>
<tr>
<td>70-100</td>
<td>4</td>
<td>22-27</td>
</tr>
</tbody>
</table>

Table (2) Climatic data

- **Relative humidity**
  
In table (3) the data of relative humidity is classified into groups according to table (5).

<table>
<thead>
<tr>
<th>Relative Humidity</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly mean max</td>
<td>80</td>
<td>78</td>
<td>80</td>
<td>74</td>
<td>87</td>
<td>86</td>
<td>85</td>
<td>81</td>
<td>87</td>
<td>81</td>
<td>80</td>
<td>79</td>
</tr>
<tr>
<td>Monthly mean min</td>
<td>51</td>
<td>50</td>
<td>53</td>
<td>43</td>
<td>63</td>
<td>62</td>
<td>63</td>
<td>58</td>
<td>57</td>
<td>57</td>
<td>52</td>
<td>54</td>
</tr>
<tr>
<td>Average</td>
<td>65.5</td>
<td>64</td>
<td>66.5</td>
<td>58.5</td>
<td>75</td>
<td>74</td>
<td>74</td>
<td>71.5</td>
<td>72.5</td>
<td>69</td>
<td>66</td>
<td>66.5</td>
</tr>
<tr>
<td>Humidity group</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Table (3) Classifications of the relative humidity

- **Precipitation and wind**
  
Rainfalls and winds are investigated to get average of rainfalls, which are evaluated by (410) mm; while the winds directions are being significantly tabulated with their type as shown in table (4), which will be conducted to tables (7), (8).

<table>
<thead>
<tr>
<th>Rainfall and wind</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall mm</td>
<td>113.2</td>
<td>67.1</td>
<td>37.3</td>
<td>10</td>
<td>1.5</td>
<td>0.7</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td>23.3</td>
<td>60.89</td>
<td>5.8</td>
<td>410</td>
</tr>
<tr>
<td>Wind prevailing</td>
<td>SW</td>
<td>SW</td>
<td>SW</td>
<td>SW</td>
<td>NW</td>
<td>NW</td>
<td>NW</td>
<td>NW</td>
<td>NW</td>
<td>W</td>
<td>SW</td>
<td>SW</td>
<td></td>
</tr>
<tr>
<td>Wind secondary</td>
<td>SW</td>
<td>SE</td>
<td>SE</td>
<td>SE</td>
<td>W</td>
<td>W</td>
<td>W</td>
<td>W</td>
<td>NW</td>
<td>NW</td>
<td>SW</td>
<td>SE</td>
<td></td>
</tr>
</tbody>
</table>

Table (4) Rainfall and wind

(b) Comfort limits

Comfort limits are classified according to the average percentage of relative humidity (RH%) and to the annual mean temperature (AMT) as in table (5).
Table (5) Comfort limit

Moreover, tables (5) supports table (3) and (6) to find out the classifications of relative humidity and thermal stresses during the year.

(c) Diagnosis

Diagnoses the earlier data to get classified thermal stresses data during each month’s day and night; therefore required times and strategies could have been achieved to undertake building during the year as established in table (6).

<table>
<thead>
<tr>
<th>AMT&gt;20</th>
<th>AMT 15-20</th>
<th>AMT&lt;15</th>
</tr>
</thead>
<tbody>
<tr>
<td>RH</td>
<td>Day</td>
<td>Night</td>
</tr>
<tr>
<td></td>
<td>Lower-Upper</td>
<td>Lower</td>
</tr>
<tr>
<td>0-30</td>
<td>1</td>
<td>26-34</td>
</tr>
<tr>
<td>30-50</td>
<td>2</td>
<td>25-31</td>
</tr>
<tr>
<td>50-70</td>
<td>3</td>
<td>23-29</td>
</tr>
<tr>
<td>70-100</td>
<td>4</td>
<td>22-27</td>
</tr>
</tbody>
</table>

Table (6) Diagnosis

Table (7) shows the classification of the humid and the arid indicators that combine with the previous tables for achieving table (8).

<table>
<thead>
<tr>
<th>Type</th>
<th>Indicator</th>
<th>Thermal stress</th>
<th>Rainfall</th>
<th>H.G</th>
<th>Monthl MeanRange</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air movement essential</td>
<td>H1</td>
<td>H</td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Air movement desirable</td>
<td>H2</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rain protection Necessary</td>
<td>H3</td>
<td>&gt;200/month</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal capacity necessary</td>
<td>A1</td>
<td>I-3</td>
<td></td>
<td>&gt;10</td>
<td></td>
</tr>
<tr>
<td>Outdoor sleeping desirable</td>
<td>A2</td>
<td>H</td>
<td></td>
<td>1-2</td>
<td></td>
</tr>
<tr>
<td>Outdoor sleeping desirable</td>
<td>A3</td>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table (7) The humid and arid indicators

An initial response is represented in indicators form and is shown in table (8), which is related to the previous tables. The whole procedure is carried out to insert the results into table (9) to get design recommendations for proposed buildings.

<table>
<thead>
<tr>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>I</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table (8) Indicators

(d) Design recommendations

Mahoney’s table (9) consists of 8 fields to find out the way of developing housing designs from the sketching stage until the construction.
Table (9) Mahoney’s table

In table (10) assembling the previous mentioned recommendations as one unit in total.

Table (10) Recommendations for Gaza’s building design

4. ANALYSIS
Different approaches have been adopted to determine the needed tools to achieve thermal comfort through the analysis of charts and tables. Accordingly, the percentage of the twelve lines in the Givoni and Olgyay charts is approximated according to its location to the comfort zone and it was noticed that the solar radiation utilized about 55% of the year in Olgyay’s chart and regarded as the most effective tool for heating to restore thermal comfort in a building whereas 47% as a passive heating is achieved from Givoni’s chart and 45% from Mahoney table. In the Givoni chart, natural ventilation represents 32% of the year whereas Olgyay’s chart represents about 30% of the year and
Figure (3) Application of (Olgyay-Givoni-Mahoney) methods to Gaza

Figure (4) Model’s Plans

Figure (5) longitudinal section of “summer’s case in the nighttime” and “winter’s case in the daytime

5. SIMULATION’S MODEL

The preceding results clarified the needed percentages of cooling and heating during the year. Therefore, an integrated design with natural ventilation, southern solar panels and floor radiant cooling and heating system, in which pipes of cold and hot water are embedded inside the concrete floor slabs has been implemented to lessen pollution within low energy concepts. Moreover, analyzing the indoor environmental conditions of many parametric study’s cases will achieve the optimal case of Gaza’s human comfort model. Proposed building for simulation consists of two floors and penthouse with entirely approximated gross area of 134m². Moreover, ventilation processes are conducted throughout the stairwell. For evaluating the performances of the proposed building, it has been divided into seven zones as shown in figure (4), (5). The hottest and coldest day of the year were used for the numerical simulations. Moreover, the list of the conducted simulation conditions is shown in tables (11), (12).
5.1 Results and discussion

Case (1)
The original case has been typically represented by case (1) as shown in table (11), (12). Moreover, openings are being actualized for the current dimensions “M.O”.

In summer
It is noticed that, indoor air temperature has an increased average about (+5.31) °C, to reach (35.56) °C, while the average outdoor air temperature was (30.25) °C as shown in figure (6). Moreover, it is being laid outside the thermal comfort zones. A difference of average air temperature between the basement and outdoor shows (+1.45) °C; while about (+8) °C between the penthouse and the outdoor. Therefore, it is noticed that, the temperature has accumulated gradually from the lower degree of the basement floor to the higher degree at upper floors, which in turn compel one to examine some design tools to evaluate the temperature.

In winter
Minimum outdoor air temperature was about (4.01) °C in the coldest day of the year and the average air temperature was about (6.90) °C. A difference of air temperature between higher floors and outdoor shows an increase of (+1.5) °C that reaches the average temperature to (8.40) °C. The indoor air temperature has an increased average about (+0.5) °C, to reach average of (7.3) °C, while; the basement has an average difference of (- 0.5) °C with average of (6.4) °C as shown in figure (6) i.e. higher floors
have higher temperatures than lower floors, due to the differences of solar gains and thermal performances. Nevertheless, the calculated temperatures lay out the bioclimatic thermal comfort zone. This practice ensures that the existing buildings deal summer rather than winter.

➢ **Case (2)**
To achieve healthy buildings, ventilation is needed through summer and winter. This case conducted the ventilation and compared to the non-ventilated case.

**In summer**
It is noticed that the accumulated heat inside the living spaces is being decreased during morning times and nighttimes to have a difference of up (-2.70) °C, (-1.65) °C in the basement and (-3.32) °C in the penthouse as shown in figure (7). Therefore, ventilation has obviously affected and activated the air to lessen a gradient of temperature.

**In winter**
Being compared to the original case, it has been noticed that ventilation reduced the average temperature inside spaces of (-0.45) °C. Therefore airtight buildings as shown in figure (7) are desirable. Therefore, sizing orifices are a significant study and should be studied for achieving more distinctive thermal comfort.

➢ **Case (3b1)**
Shading devices with wall type-A with the absence of ventilation are being practiced in this case to emphasize the effect of shading devices by reducing the transmitted solar radiation especially during hot and sunny days.

**In summer**
This practice has been compared to the original one to examine shading devices. Therefore, a significant
difference of temperature of up (-2.6) °C shows an improvement in the penthouse and (-0.6) °C in living spaces as shown in figure (8), while in winter there is almost no difference due to the altitude angle, which causes a capability for penetrating the spaces.

➢ Case (3b2)

For mitigating the thermal environment of indoor spaces, it has combined the ventilation with walls type-A and the shading devices, which reduce the solar radiation in the building during the summer season.

In summer

This practice is compared to case (1) and it is noticed that the temperature is being reduced to (-2.9) °C in living spaces, (-1.8) °C in the basement and (-4.70) °C in the penthouse as shown in figure (9). Moreover, shading devices prevent the solar radiation from penetrating while ventilation improves the thermal environment. Therefore, temperature is reduced inside spaces to (-3.2) °C.

In winter

The shading devices have almost no effect during winter, while ventilation should be controlled during the winter case. It has been noticed that temperature in living spaces has been reduced to (-0.4) °C and (-0.65) °C in the penthouse as shown in figure (9), while at the base case it showed an improvement unlike this case due to the ventilation performances.

➢ Case (4)

For improving the thermal environment of indoor spaces, insulation within walls-B and roofs, shading devices and small openings are being conducted. Moreover, this case is carried out with the absence of ventilation in both cases.

In summer

Comparing this practice to the original case, a gradient temperature is improved of up (-1.80) °C on living spaces and (-4.5) °C on penthouse’s space, due to the efficiency of shading devices and to the insulation, which is reducing the heat transfer. Therefore, temperature is improved inside spaces as shown in figure (10).

In winter

It shows an improvement of about (+0.75) °C in living spaces and (+1.05) °C in the upper spaces as shown in figure (10). Therefore, it indicates that there may be room for modest modification of Mahoney data. For example utilizing insulated roofs and walls
with small windows is more convenient, i.e. insulation proved to be the way for maintaining the indoor thermal environment and reducing heat transfer.

➤ **Case (5)**

Properly, the previous case (4) is being conducted with ventilation but without high technology evaluations such as exploiting the solar energy by solar panels. It has been compared to the current situation during the years and has been noticed.

**In summer**

Obviously, an improvement of temperature about \((-3.87)\) °C is being shown in living spaces, \((-1.92)\) °C in the basement, while about \((-6)\) °C in the penthouse. The temperature in living spaces reached average of \((31.80)\) °C, \((29.8)\) °C in the basement spaces and \((32.16)\) °C in the penthouse as shown in figure (11). Generally, the average indoor temperature considered about \((31.20)\) °C. Temperature is decreased due to the smaller openings dimensions with the shading devices, thermal massive walls and natural ventilation, which in turn reduced the indoor temperature. Therefore, the natural tools could mitigate the climatic severe problems of Gaza. Moreover, this practice has been interpreted and joined strongly with Mahoney’s recommendations.

**In winter**

The ventilation negatively affected the interior spaces, while opposite occurs where insulation is used. Thus, a small improvement of temperature about \((+0.5)\) °C is being shown in the living spaces and kept the internal temperature stable as much as possible as shown in figure (11) due to the same earlier interpretations, and this case still tackled only warm temperatures.

➤ **Case (6)**

The previous case (5) integrated solar panels (36 m²), floor pipes on the first and the second floor, an automatic pump and shutters.

**In summer**

Water flows into floors through embedded pipes. This system is supported by an automatic pump, which works during the summer’s nighttimes. Moreover, a sensor is used for controlling movement of shutters, which are shutting the panels during the daytime and opening them during the nighttime. Comparing this case to the original one, it has been noticed that an improvement in temperature of \((-4.4)\) °C in living spaces to reach maximum average of \((30.8)\) °C and about \((-7)\) °C in upper spaces to reach maximum average of \((31.3)\) °C as shown in figure (12a). Moreover, water temperature of panels was cooler than indoor spaces by \((-2.3)\) °C, thus it has enhanced the natural cooling system inside spaces. Therefore, it is reasonable to exploit and utilize the solar panels to reduce the gradient
Shutters shut the panels during the nighttime and will open them during the daytime with running water in the pipes during the daytime. Comparing this case to the original one, it is noticed that a considerable improvement of temperature of (+13.5) °C inside the building. Therefore, this practice successfully tackled the heating system of living spaces during the cold weather, as shown in figure (12b).

6. SUMMARY AND RECOMMENDATIONS

For achieving the thermal comfort zone of the original case, it was noticed that the needed temperature of [(6.5) °C cooling, (13.5) °C heating] in living spaces, where in the case (5), consists of (shading devices, insulation, ventilation and small openings with double glass panes), required [(2.2) °C cooling, (13.4) °C heating], but in the case (6) it was noticed that [(1.8) °C cooling, (0) °C heating]. Accordingly, results of Gaza are satisfied; hence the required energy to cover a difference of temperature was low. Therefore, the most effective parameters have been gradually assembled to develop the thermal environment of indoor spaces in summer were "Ventilation, insulation, solar shading and shading devices"; while in winter were "the solar panel and thermal insulation". Therefore, assembling the most effective and natural parameters, which developed the thermal environment of indoor spaces is desired to lessen the environmental pollution with low energy consumption. Accordingly cases (5) and (6) have achieved high thermal environment with its positive impact in terms of sustainability. Therefore, it is recommended to adopt them through the design processes. Moreover, design’s characteristics of cases (5), (6) are economic affordability, applicability and reliability, i.e. the most effective strategies of green’s design have been maintained for Gaza city.

7. REFERENCES