CONSTRUCTION INDUSTRY ON THE RENEWABLE ENERGY BANDWAGON

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ABSTRACT

The construction industry contributes substantially to environmental degradation, partly due to its large consumption of energy. In particular, energy consumption in buildings has grown in aggregate over time and thus the greenhouse gas emissions associated with non-renewable energy use. Thus, analysis of the energy consumption of buildings is a difficult task, as it requires considering the detailed interactions between different components. Driven by population and economic growth, energy demand is expected to rise accompanied by further environmental concerns.

As buildings are long-lived, impacts of direct and indirect energy uses will stretch into the lives of future generations. With the worldwide trend to combat the harmful effects of conventional energy, renewable energy sources come to forefront. This study shed light on Gaza Strip construction industry by presenting results of a questionnaire survey conducted among 57 consulting offices. The research examined the alternative energy sources in place, criteria for selection and general satisfaction.

Generally, results revealed that generators, batteries and solar cells are the alternative energy sources used in the surveyed consulting offices. In addition, the vast majority of the respondents were dissatisfied with the current alternative sources. Collectively, to ensure that the problem is brought under control, a broader boundary for considering the use of renewable-energy sources must be created.

Key words: Construction, Gaza Strip, Renewable energy.

http://www.iaeme.com/ijm/issues.asp?JType=IJM&VType=7&IType=4
1. INTRODUCTION

At present, a large amount of used energy is derived from conventional sources of energy which considered being exhaustible. Furthermore, production and use of such energy create a series of environmental problems; the most serious related to carbon dioxide generation that adds to green house effect. In contrast, renewable energy is energy which can be secured from natural resources and constantly being replenished. It can be classified into five main forms: Solar Photovoltaic (PV), Wind, Tidal power, Geothermal and Biomass. Renewable energy provides a reliable and resilient energy sources and clearly have environmental advantages over conventional sources. In essence, there is an urgent need for transition from conventional-based energy sources to renewable resources to decrease reliance on depleting reserves and to mitigate climate change.

In particular, the construction sector is responsible for an intensive use of non-renewable energy; from the production of materials to the building process itself. As buildings are long-lived, impacts of direct and indirect energy uses will stretch into the lives of future generations. In case of construction, direct energy is the energy consumed on site during the development of buildings as well as energy used by the construction firm. Meanwhile, indirect use of energy is associated with construction processes; for example: material production. Most research to-date has tended to focus on assessing direct energy use attached to buildings development; yet, little attention has been paid to energy use by construction firms. Firms utilize a large number of technologies for heating, cooling, and lighting, and a wide range of appliances. In this context, companies within the industry are on the hook to find ways to secure clean energy source that meets the demand. Achieving such target is a major challenge as demand for energy increases, particularly with the accelerating development in countries around the world.

With the worldwide trend to combat the harmful effects of conventional energy, renewable energy sources provide reassurance against the growing concern of environmental degradation and energy security. The focus of this paper is on the energy end-user, as this paper investigates the challenges and options available to improve energy efficiency within the construction sector in the Gaza Strip.

2. LITERATURE REVIEW

The construction industry substantially uses non-renewable energy which adversely impacts the surrounding environment. In particular, energy services in buildings are responsible for a significant share of energy use worldwide. Explicitly, the demand for energy services in buildings varies widely according to geography, culture, climate, and the level of economic development (Hosein, et al. 2013). It also differs by the type of use, ownership status, age, and location of buildings. In essence, the level of service and quantity of energy provided depend on many factors including: the type of development, employed technology, culture and personal behavior. Consequently, analysis of energy demand is a complex task as interactions between presented factors need to be taken into account.

The U.S. Environmental Protection Agency defines “Green Building, also known as “Sustainable” or “High Performance” building, as: “…the practice of creating structures and using processes that are environmentally responsible and resource efficient throughout a building’s life-cycle from sitting to design, construction, operation, maintenance, renovation and deconstruction”. This practice expands and
complements the classical building design concerns of economy, utility, durability, and comfort.

With the worldwide initiatives for moving towards clean energy sources, a sustainable plan must be implemented. In essence, usage of renewable energy sources in the context of sustainability have been addressed and discussed from various dimensions in literature. For instance, Nieves and Río (2010) reviewed the contribution of renewable energy sources to the energy sustainability of islands with the focus on the used methodologies. Meanwhile, other explored the impact of sustainable construction and knowledge management on sustainability goals (Pietrosemoli and Monroy, 2013). Furthermore, Dikmen and Gultekdn (2011) discussed the role architects, designers take in creating a more sustainable buildings providing renewable energy use. Drivers and Factors affecting the growth of green building in South African construction industry have also been examined ((Windapo, 2014) and (Simpeh and Smallwood, 2015)).

From the above discourse, the role of renewable energy sources in promoting sustainability has been advocated.

3. THE GAZA STRIP
Gaza is a narrow strip of land along the Mediterranean coast consisting of five governorates including Gaza, Middle, Northern, Khanyounis and Rafah. With population of approximately 1.7 million and a total area of 365 km², it is considered to be one of the most populated regions across the world. In this area, the current demand of electric power is approximately 350 Megawatts (MW). The vast majority of needed power is imported; from Israel, 120 MW or from Egypt, 22 MW. Gaza Power Plant (GPP) is the sole electricity generation facility in Gaza functioning at only 65% of its design capacity and contributing to 92 MW to the overall demand. Considering this situation, Gaza This chronic electricity deficit and power cuts disrupt almost all aspects of civilian life as it mainly influence the delivery of basic services, consequently, the area is in urge need to find alternative energy source.

4. METHODOLOGY
The research began with a review of material; journals, text books and internet information, related to renewable energy sources. Then, the data for this study was gathered by a mean of questionnaire survey; self administrated to 57 consultant’s offices located in the Gaza Strip. Forty nine questionnaires were collected with a response rate of 86%. The questionnaire was divided into two main sections. One was an introductory section consisting of general questions about the consulting offices. Meanwhile, the second section concerned with data related to alternative energy sources. The second section was divided into sub-sections consisting of: electricity need, offices reliance on public network, nature of devices, monthly electricity bill, types of used alternative energy sources, daily operating hours, drivers to choose the alternative source and selection criteria. A combination of multiple-choice questions and open-ended questions were employed in the questionnaire; some requesting quantitative data, while, some requesting qualitative information. Thus, clear instructions of how to fill in the questionnaire have been provided. Two versions of the questionnaire were distributed, one in Arabic and the other in English. The collected questionnaires, from GS consultants, were processed using the Statistical Package for Social Science (SPSS).
5. RESULTS
Analysis for both parts of the questionnaire is presented.

5.1. Part One: General Information:
Results indicated that 83% from the consultants offices located in Gaza governorate, (14.7%) from sample located in Northern governorate, and only 2.3% from Middle governorate. In addition, 59.2% of employees in consultant’s offices work as office directors, 18.4% work as design engineer, and with similar percent, of 18.4%, work as supervisor engineers. Apparently, this reveals high levels of engagement in the survey among office-based staff; directors and design engineers. Results also clarified that 67.3% from consultant’s offices in Gaza strip are owned offices, on the other hand, 32.7% are rent offices; reflecting the preference of decision-making level on the offices.

Furthermore, 42.9% from consultant offices have practical experience of (11-15) years, meanwhile, 22.4% have practical experience for more than 15 years, 18.4% less than 5 years, and 16.3% have practical experience of (5-10) years. Finally, results shows that 59.8% of the consultant’s offices work for 7-10 hours per day, 20.6% for more than (10) hours, meanwhile, 14.3% for (5-6) hours, and (5.3%) for (1-4) hours per day. Although there is a deficit in electricity energy, 80% of consulting offices work for more than (7) hours per day.

5.2. Part Two:

5.2.1. Office Supply Electricity Source.

<table>
<thead>
<tr>
<th>Office Electricity Supply Source</th>
<th>No</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaza Power Station</td>
<td>42</td>
<td>85.7</td>
</tr>
<tr>
<td>Egypt</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Israel</td>
<td>5</td>
<td>10.3</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>49</td>
<td>100</td>
</tr>
</tbody>
</table>

Table (1): Office Supply Electricity Source

5.2.2. Office Reliance on Public Electricity Network as a Source of Power (hour per day):

<table>
<thead>
<tr>
<th>Office Reliance on public network (h/d)</th>
<th>No</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>From (1-6)</td>
<td>16</td>
<td>32.7</td>
</tr>
<tr>
<td>From (7-12)</td>
<td>33</td>
<td>67.3</td>
</tr>
<tr>
<td>Total</td>
<td>49</td>
<td>100</td>
</tr>
</tbody>
</table>

Table (2): Office Reliance on Public Network

Results presented in Table (1) revealed that most of the surveyed offices, with 85.7%, depend on Gaza Power Station (GPS) as a main source of energy supply. As
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GPS only supplies 92 MGW, from the Gaza Strip demand of 350 MGW, a high deficiency is perceived. Meanwhile, Table (2) shows the number of hours of which offices relies on public network.

5.2.3. The nature of the devices in the office:

<table>
<thead>
<tr>
<th>Nature of the devices</th>
<th>No.</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>laptops</td>
<td>39</td>
<td>79.6</td>
</tr>
<tr>
<td>PC</td>
<td>40</td>
<td>81.6</td>
</tr>
<tr>
<td>Scanner</td>
<td>28</td>
<td>57.1</td>
</tr>
<tr>
<td>Printers</td>
<td>46</td>
<td>93.9</td>
</tr>
<tr>
<td>Fax</td>
<td>41</td>
<td>83.7</td>
</tr>
<tr>
<td>Air Condition</td>
<td>29</td>
<td>59.2</td>
</tr>
</tbody>
</table>

Table (3): Nature of Devices

A typical office environment comprises different devices as shown in Table (3). Such devices should provide key function within the office. In effect, they are likely to be operated for a long time; aligned with the different tasks attached to the offices.

5.2.4. Monthly Electricity Bill Rate:

<table>
<thead>
<tr>
<th>Average Electricity Bill (/month)</th>
<th>No</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>From (150-200)</td>
<td>22</td>
<td>44.9</td>
</tr>
<tr>
<td>From (200-400)</td>
<td>19</td>
<td>38.8</td>
</tr>
<tr>
<td>From (400-600)</td>
<td>3</td>
<td>6.1</td>
</tr>
<tr>
<td>More than (600)</td>
<td>5</td>
<td>10.2</td>
</tr>
</tbody>
</table>

Table (4): Average Electric bill per month

The monthly average electric bill varies widely among respondents; with the lowest average of 150 NIS and highest on average of 600 NIS as shown in Table (4). As running the office can be difficult venture, adding another energy source to cover the shortage is making the task even harder.

5.2.5. Alternative sources of energy used in consulting offices in Gaza strip

Participants were asked to indicate the type of energy source including; solar cells, wind energy, biomass, batteries and generators, used to cover energy shortfall related to the number of hours. A broad consensus among respondents was that wind energy and biomass are not used as an alternative source to cover their energy demand.
Similarly, 87.8% of respondents do not use solar cells as a source of energy, see Figure (1). On the other hand, batteries and generators are used with the most common being in favor of generators. Daily operating hours for the energy source relate to number of working hours.

Table (5, 6 and 7), present the number of daily operating hours for the chosen energy source related to number of working hours.

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of operating hours per day</th>
<th>Number of working hours per day</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(1-4)</td>
<td>(5-6)</td>
</tr>
<tr>
<td>Generators</td>
<td>Not use</td>
<td>66.7%</td>
<td>28.6%</td>
</tr>
<tr>
<td></td>
<td>(1-2)</td>
<td>0.0%</td>
<td>14.2%</td>
</tr>
<tr>
<td></td>
<td>(3-4)</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>(5-6)</td>
<td>33.3%</td>
<td>42.9%</td>
</tr>
<tr>
<td></td>
<td>(7-8)</td>
<td>0.0%</td>
<td>14.3%</td>
</tr>
<tr>
<td></td>
<td>More than 8</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

Table (5): Operating Hours related to Working Hours – Generators

Analysis of obtained results show that 66.7% of consulting offices which operate daily from (1-4) hours don’t need generators, while, 70% of the consulting offices working for more than 10 hours need to operate generators for (3-4) hours.

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of operating hours per day</th>
<th>Number of working hours per day</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(1-4)</td>
<td>(5-6)</td>
</tr>
<tr>
<td>Batteries</td>
<td>Not use</td>
<td>0.0%</td>
<td>28.6%</td>
</tr>
<tr>
<td></td>
<td>(1-2)</td>
<td>66.7%</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>(3-4)</td>
<td>0.0%</td>
<td>14.3%</td>
</tr>
<tr>
<td></td>
<td>(5-6)</td>
<td>33.3%</td>
<td>57.1%</td>
</tr>
<tr>
<td></td>
<td>(7-8)</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table (6): Operating Hours related to Working Hours – Batteries
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Analysis of obtained results show that 66.7% of consulting offices which operate daily from (1-4) hours need to use batteries for (1-2) hours, while, 60% of the consulting offices working for more than 10 hours need to operate generators for (5-6) hours.

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of operating hours per day</th>
<th>Number of working hours per day</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar cells</td>
<td></td>
<td>(1-4)  (5-6)  (7-10)  More than 10</td>
<td></td>
</tr>
<tr>
<td>Not use</td>
<td>100%</td>
<td>57.1%  93.1%  90%  87.8%</td>
<td></td>
</tr>
<tr>
<td>(1-2)</td>
<td>0.0%</td>
<td>42.9%  3.4%  0.0%  8.20%</td>
<td></td>
</tr>
<tr>
<td>(5-6)</td>
<td>0.0%</td>
<td>0.0%   10%  2.0%</td>
<td></td>
</tr>
<tr>
<td>(7-8)</td>
<td>0.0%</td>
<td>0.0%   3.4%  0.0%  2.0%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%   100%  100%  100%</td>
<td></td>
</tr>
</tbody>
</table>

Table (7): Operating Hours related to Working Hours – Solar Cells

Results from Table (7) show that all consulting offices which work daily from (1-4) hours and similarly, for more than 10 hours do use solar cells. In addition, respondents working for (5-6) hours need to use solar cells for (1-2) hours.

<table>
<thead>
<tr>
<th>Source of alternative energy</th>
<th>Floor</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First  Second  Third  More than Fourth</td>
<td></td>
</tr>
<tr>
<td>Generators</td>
<td>5  4  4  0  13  55.60% 33.30% 25.00% 0.00% 26.50%</td>
<td></td>
</tr>
<tr>
<td>Batteries</td>
<td>4  2  1  10  17  44.40% 16.70% 6.30% 83.30% 34.70%</td>
<td></td>
</tr>
<tr>
<td>Generators and Batteries</td>
<td>0  6  6  1  13  0.00% 50.00% 37.50% 8.30% 26.50%</td>
<td></td>
</tr>
<tr>
<td>Generators, Batteries and solar cells</td>
<td>0  0  3  1  4  0.00% 0.00% 18.80% 8.30% 8.20%</td>
<td></td>
</tr>
<tr>
<td>Generators and Solar cells</td>
<td>0  0  2  0  2  0.00% 0.00% 12.50% 0.00% 4.10%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>9  12  16  12  49</td>
<td></td>
</tr>
</tbody>
</table>

Table (10): Alternative Energy Source and Office Level

Studying different combinations of energy sources used in the consulting offices and offices levels (Table 10), batteries are the most widely used, followed by
generators with similar percentage accounted for both generators and batteries. With the least common recorded for generators and solar cells.

5.2.6. Drivers for Alternative Energy Source

<table>
<thead>
<tr>
<th>Based on the fluctuating state of electricity coming from the public networks</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Don’t Agree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The public electricity network is in line with working hours.</td>
<td>0</td>
<td>2</td>
<td>24.5</td>
<td>32.7</td>
<td>40.8</td>
</tr>
<tr>
<td>General production office negatively affected by the fluctuating of electricity.</td>
<td>57.1</td>
<td>22.4</td>
<td>16.3</td>
<td>4.1</td>
<td>0</td>
</tr>
<tr>
<td>Alternative sources</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common use.</td>
<td>16.3</td>
<td>32.7</td>
<td>16.3</td>
<td>34.7</td>
<td>0</td>
</tr>
<tr>
<td>Widely available.</td>
<td>12.2</td>
<td>24.5</td>
<td>20.4</td>
<td>42.9</td>
<td>0</td>
</tr>
<tr>
<td>A solution to the problems for reaching offices in the high floors.</td>
<td>6.1</td>
<td>24.5</td>
<td>10.2</td>
<td>55.1</td>
<td>4.1</td>
</tr>
<tr>
<td>Alternative purposes, supplies, maintenance and operation source is available</td>
<td>2</td>
<td>36.7</td>
<td>26.5</td>
<td>34.7</td>
<td>0</td>
</tr>
<tr>
<td>The life cycle of the alternative source plays a key role when making a choice</td>
<td>20.4</td>
<td>57.1</td>
<td>16.3</td>
<td>2</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Table (8): The Need for Alternative Energy Sources

Analysis of results confirmed that the public electricity network is not in line with the working hours, see Table (8). Thus, 57.1 % ascertained that the office production is negatively affected by the electricity fluctuation. 49 % of respondents agree that energy alternative source is commonly used. Meanwhile, 42.9 % argues the availability of the alternative energy sources. Furthermore, 55.1% disagree that the alternative energy sources solve the problem with high offices levels. 38.7% agrees that supplies, maintenance and operation are available for the alternative energy source. Finally, 77.5% states that the life cycle of the alternative source plays a key role in making a choice.
5.2.7. Alternative Source Selection Criteria.

<table>
<thead>
<tr>
<th>Alternative source selection criteria</th>
<th>Maintenance (%)</th>
<th>Materials needed for the operation (%)</th>
<th>The availability of material required for operation (%)</th>
<th>The cost of material necessary for the operation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>From (1-20%)</td>
<td>57.1</td>
<td>44.9</td>
<td>30.6</td>
<td>6.1</td>
</tr>
<tr>
<td>From (21-40%)</td>
<td>38.8</td>
<td>22.4</td>
<td>34.7</td>
<td>44.9</td>
</tr>
<tr>
<td>From (41-60%)</td>
<td>0</td>
<td>24.5</td>
<td>14.3</td>
<td>36.7</td>
</tr>
<tr>
<td>From (61-80%)</td>
<td>0</td>
<td>4.1</td>
<td>4.1</td>
<td>4.1</td>
</tr>
<tr>
<td>From (81-100%)</td>
<td>4.1</td>
<td>4.1</td>
<td>16.3</td>
<td>8.2</td>
</tr>
<tr>
<td>total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Table (9): Alternative Source Selection Criteria

Findings from the survey revealed that 95.4% of consulting offices select the alternative energy source based on low maintenance requirements, 40%. While, 67.3% depends on the lowest percentage of material needed for operation when making the selection. The availability of these materials is another factor, which account for less than 40%. It can be concluded that the cost of the material is the main criteria accounting for almost 50%.

5.2.8. Alternative Energy Source Satisfaction

75% of the consulting offices; using generators, batteries, are not fully satisfied with these sources, as it is not covering the demand shortage. On the other hand, 25% documented full satisfaction. Also, 60% of respondents classified batteries and generators as dangerous, noisy and in certain incidents can cause damage to connected devices. In addition, all consulting offices considered both batteries and generators are operationally expensive and in need of regular maintenance. Additionally, unstable electricity supply can also lead to lower production for the offices.

6. CONCLUSION

The need for alternative energy sources is mainly attributed to the scarcity of resources and deterioration of the environment in recent decades. In particular, use of buildings is responsible for a significant share of energy-related emissions. This study investigated the challenges and options available to improve energy efficiency within the construction sector in the Gaza Strip. The results of the questionnaire show that generators, batteries and solar cells are the alternative energy sources used in the surveyed consulting offices; noting that generators are the most common while solar cells are the least common. Despite these findings, generators do not cover the deficit in electricity need, a source of air and noise pollution and documented to be expensive to operate and maintain. Similar findings were concluded in the case of batteries with the exception of being less noisy. Meanwhile, solar cells were identified as clean
energy source, though; it is uncommon among the surveyed offices. Furthermore, participants indicated that the cost of the material is the main selection criteria for the alternative source.

Overall, the vast majority of the respondents were dissatisfied with the current alternative sources in place. Furthermore, they ascertained that the office production is negatively affected by the electricity fluctuation and therefore, it is imperative for the consulting offices to adopt a more sustainable system.

REFERENCES


