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The need of sustainable buildings construction in the Kingdom of Bahrain

N.W. Alnaser*, R. Flanagan

School of Construction Management & Engineering, The University of Reading, Whiteknights, P.O. Box 219, Reading RG 6 6AW, UK

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Abstract

This thesis is aimed to initiate implementing sustainable building construction in the kingdom of Bahrain, i.e. Building-Integration PhotoVoltaic (BIPV) or Wind Energy (BIWE). It highlights the main constrains that discourage such modern concept in building and construction.

Three groups have been questioned using a questionnaire. These are the policy and decision makers, the leading consultants and the contractors. The main constrains of the dissemination of BIVP and BIWE, according to the policy and decision makers, are: lack of knowledge and awareness of the public in sustainable technology, low cost of electricity, low cost of gas and oil and difficulty in applying local environmental taxes.

The consultants had attributed the constrains to ignorance of life cycle cost of PV and Wind turbines systems, lack of education and knowledge in sustainable design, political system, shortage of markets importing sustainable technologies and client worries in profitability and pay-back period.

The contractors are found to be very enthusiastic and ready to take over any sustainable building project and prefer to have a construction manger to coordinate between the design and contracting team.

Design and Build is found the favorable procurement method in Bahrain for conducting BIPV or BIWE projects.

1. Introduction

Construction is the building or assembly of any infrastructure. Although this may be thought of as a single activity, in fact construction is a feat of multitasking. Normally the job is managed by the project manager, supervised on site by the design engineer and foreman, scrutinized closely by the stakeholders, and often, when construction delays occur, detested by the public. The successful execution of a project often is more the result of effective planning than anything else. Those involved with the design and execution of the infrastructure in question must consider the environmental impact of the job, the successful scheduling, budgeting, site safety, inconvenience to the public caused by construction delays, preparing tender documents, etc.

According to Coleman [1], construction management is about controlling time, cost, quality, and safety. It is also acting in a socially, politically, and environmentally acceptable manner.

There are many indicators for sustainable building design. Among these [2]:

(a) Identifying opportunities to generate on-site renewable electricity, i.e. like Building-Integrating Photovoltaic (BIPV).

(b) Minimizing the use of fossil-based energy in terms of energy embodied in the material, transport and construction process and energy used during the lifetime of the building.

(c) Ensuring that building management systems are user friendly and not over-complex.

(d) Making best use of passive (or active) solar energy while employing heating/cooling systems which are fine

*Corresponding author.
E-mail addresses: kcr05nwa@rdg.ac.uk, alnaserw@batelco.com.bh (N.W. Alnaser).

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tuned to the needs of the occupants with air-conditioning used only in exceptional circumstances. Among the guidance for the design of government policies to address the environmental issues related to sustainable building is reducing of CO_2 emission, minimizing of construction and demolition waste, and prevention of indoor air pollution [3].

The first installation of BIPV was realized in 1991 in Aachen, Germany [4]. The photovoltaic (PV) elements were integrated into a curtain wall façade with isolating glass. Today, photovoltaic modules for building integration are produced as a standard building product—fitting into standard façade and roof structures. These elements created a whole new market and since then building integration is one of the fastest growing market segments in photovoltaic. An impressive solar installation is the Academy Mont-Cenis in Herne (Germany)—with more than 10 000 m^2 of photovoltaic integrated into the roof and façade—and was completed in March 2001. Several other large-scale projects, worldwide, are under construction or in the planning phase [4].

Nowadays, many buildings in Bahrain—and in the region—are built without any considerations for sustainability from all stakeholders (client and policy makers), i.e. designing and constructing buildings with glass cladding and big openings which could create energy crisis and damage to the environment (emission of CO_2).

This paper will tackle the issues that prevent practicing sustainable construction (use of solar and wind energy). Also it will search for the solutions and reasons to this problem, i.e. whether the fault is attributed to the policy makers (government) or the designing team or contracting team. Furthermore, this research will identify the optimum procurement method in implementing the sustainability in construction industry in Bahrain.

Smart Architects and Customers are those who designs and plans their houses, premises and buildings considering the climatic parameters. Therefore, many scientists had published many books dealing with building according to the climate [2,5–10].

Building in warm-humid climate should be different from cold or temperature climate. The environment should be dealt by adopting energy efficient strategy. Reduction in energy consumption will have a positive impact on environment. The energy efficient design must be understood as design that minimizes energy consumption in building by using natural measures to improve comfort conditions. This is, of course, different from designs which rely on internal comfort that is achieved by mechanical cooling and ventilation equipment that consumes unnecessary fuel for its operation, and hence, spoil the environment. Unfortunately, because of ignorance of building design that tolerate naturally with the climate, we had come to find that typical air-conditioned building, in Bahrain and Arabian Gulf regions, contribute to 70–80% of its lifetime total energy consumption for operating these systems for internal comfort although we are currently running in energy crises.

At present, 83% of the global energy produced is consumed by only 25% of the world's population, living on 17%, at the disposal of the remaining 75% of the world's population (who live in mainly in the developing world). The situation will be critical when knowing that 60–70% of the total world population of the developing world is now living in urban areas [11].

Building a construction that is passive to solar radiation in hot, humid and high solar intensity countries, such as Bahrain and GCC and other Arab countries (solar belt), will result in the waste of mechanical energy for air-condition. The energy from the traditional sources (oil and gas) cannot be supplied without the use of a considerable amount of energy. The total efficiency of the system from the extraction of resources, preparation, transport, conversion and distribution to application may be up to 20%, that it takes approximately 5 kWh to deliver 1 kWh of energy.

Thinking about building in harmony with the climate, or using renewable energy resources, is a positive practice. As example, it is well known that in hot dry regions the built environment should be planned compactly to reduce the amount of surfaces exposed to solar radiation. In warm humid regions, buildings should be openly spaced to maximize air movement between individual buildings.

2. The climate of Bahrain

The kingdom of Bahrain consists of a group of about 35 island, situated midway along the Arabian Gulf, approximately 24 km from the east coast of Saudi Arabia (which is linked by a causeway), and 28 km from the west coast of Qatar (which will be linked to it by a causeway in 2008). It is located between latitudes 25°32′ and 26°20′ N and longitude 50°20′ and 50°50′ E. Bahrain's climate is characterized by a very high average temperature and relative humidity during summer.

The mean daily maximum temperature ranges from 34.1 °C, in May, to a maximum of 38 °C, in August, while the mean daily maximum relative humidity ranges from 79% to 83% during this period, respectively. During the winter season the mean daily minimum temperature ranges from 14.1 °C, in January, to 16.2 °C, in December. On the other hand, the mean daily hours of sunshine range from a minimum of 7.3 h, in January, to a maximum of 11.3 h, in June [9].

The wind speed in Bahrain is moderate. The average annual wind speed is nearly 5 m/s and its mainly North to North West. Since Bahrain is an island then the sea and land breeze assures the availability of the wind most of the year. June is the windiest throughout the month and noon is the windiest throughout the day.

The solar radiation intensity in Bahrain is very high, ranging from a minimum of 3.25 kWh/m^2, in December, to a maximum of 7.19 kWh/m^2, in July [12].

3. Building-integration photovoltaic (BIPV) or wind energy (BIWE)

Solar today magazine [13] had highlighted on Solar in the City. It had shown a 4-story wing built (Morgenthau Wing) at a Museum in Lower Manhattan, including 3500 ft^2 of PV of cost $60 m giving 36.5 kW peak capacity (330,110 W PV modules with 20 kW invertors). It also had shown how is the solar electric sunshades will look like when the project of US Mission Building is completed. The US government had awarded a $1.3 million contract to three Swiss companies to install a 958 m^2 (910,22 6 ft^2) building integrated solar energy system (BIPV) on building the US Mission to United Nations in Geneva, Switzerland. At peak capacity, the installation is expected to produce 118 kW, enough electricity to power 37 average homes. The work started on 9 June 2004 and completed on November 2004!

Furthermore, a PV system was built in USA and was consisting of 324 solar panels providing 51 kW—which provides 50% of electricity needed for the apartment complex in Buena Park in USA. The arrays was installed on the roof of its tenant parking garage [14]. More interesting, in London, the Richmond Fire Station in South West will soon be fully solar powered. This station is one of more 100 solar projects that have won government backing as part of UKs pledge to reduce carbon dioxide emissions 60% by 2050 [14].

Roofs, especially in Arab region (Sun Belt) should be used to install PV or Solar Thermal devices. In fact, USA had launched the Million Solar Roofs initiative in 1997. One million US buildings should be facilitated to install solar energy systems by 2010 [15]. New nanotechnology could increase today's solar cell and module efficiencies by a factor of two and reduce material cost, as well [14].

Solar cell improvement has raised the sunlight-to-conversion efficiency from 6% in 1954 to a world-record 37.3% today. Now, we have solar array standing more than 50 ft high and generate 25 kW of electricity [15].

Engineers, architects, policy makers, and customers should realizes that the cost of Solar energy systems, and other renewable energies technology, had reduced nearly by a factor of 6 (from 100 cents/kWh in 1980 to only 10 cents/kWh for PV and from 60 cents/kWh to 5 cents/kWh for solar thermal [13].

The electricity use pattern per household (average of nearly 80 000), in Bahrain in 1992 [10], shows that typical summer consumption per month was 3.190 kWh while in winter was only 1.1 kWh.

Solar cooling, or special design and management can also be made toward the end use electricity consumption in Bahrain. If solar cooling is not possible for its cost then one can use it for water heating.

In fact, if solar water heating is used in all buildings in Bahrain then at least 5–10% of the consumed electricity will be saved. This technique is been very popular in many Arab countries such as Jordon, Egypt, Syria, Palestine, Tunis, and Morocco.

Therefore, our work is dedicated to the investigation of why large construction projects do not utilize the solar and wind energy, i.e. sustainable building design and construction (BIPV or BIWE). Such projects are absent in Bahrain, although Bahrain has a very high solar energy potential and moderate wind power. This was made by making interviews and short questionnaires, targeting the decision and the policy makers, as well as the contractors and design team (architects). Bahrain cannot stand idle in this regards. Even if the oil and gas is produced locally to produce electricity and desalinated water, the level of CO_2 per capita will boost even further.

Recently, the officials in Bahrain had signed an agreement to buy natural gas from Qatar. This means that the situation of the energy prices and economy will be subjected to a transition stage. This, in turn, will affect all large-scale construction projects, investments and the lifestyle.

Recently, the most common procurement method in Bahrain—for large construction projects—is Design and Built and construction management. Herein, these two methods will be evaluated in order to assess which one among them is the most suitable in implementing sustainability in large construction projects.

4. Methodology

Nobody had witness projects, neither in governmental nor in private sector, that utilizes the solar and wind energy in Bahrain, although their potential is relatively high. Some put the blame on the lack of knowledge of the *architects* in solar and wind energy and therefore they are not capable or interested in advising the policy makers or investors. Others blame the *policy and decision makers* for not using the solar technology, either because of their absent awareness on environment and how can solar and wind energy can be the remedy for futuristic demand on electricity and water or because of political, economical and technical aspects related to this issue. Other attribute this absence of utilizing solar and wind energy technology in Bahrain for large projects to the, probably, the incapability of local contractors to handle such projects. While the rest attribute the absence of the utilization of solar energy in building construction to consultants (architectural designers).

In order to search for reasons of why the applications of solar and wind technology (sustainable energy) are absent and scarce in the kingdom of Bahrain we had prepared a brief survey. We are targeting in this survey the architects, the policy and decision makers, and the contractors, i.e. the triangle of building development (TBD).

We had made three different questionnaires for each element of the TBD. We had neglected the customer because we were aiming for very large governmental commercial complexes or sky scrapers and not houses or villas as the former require much higher electrical power (nearly 5 MW) while the later no more than 0.2 MW.

These three questionnaires are planned so that they are filled directly by the researcher in an interview session. This is to avoid seeking the assistance from references for the technical questions incorporated in the questionnaire, instead of relaying upon the person current knowledge.

The three questionnaires are illustrated in the following pages with their answer (Appendix A). The Chairman of the Bahraini council of representative, Chairman of the Bahraini Consultative (Shura) Council (Both councils represent the National Council), the under-secretaries, or their assistance, of the Ministry of Electricity, Ministry of Housing and Works, and the Ministry of Municipality were consulted. For the contractors and architects, we had consulted the most popular and leading firms in Bahrain. Appendix B lists the sectors that were kind enough to answer the questionnaire.

5. Results and discussion

We have successfully managed to interview 7 Policy and Decision Makers in Bahrain (although the project was in summer holiday, in particular June and July), 10 leading consultants (Architectural companies), and 14 leading contractors (construction companies) in the kingdom of Bahrain. The results of the questionnaire are displayed between parentheses in Appendix A.

The most striking output of this questionnaire is that 100% of the policy makers feel it is important to integrate solar and wind electricity in the large building, especially after the implementation of Kyoto convention in February 2005. Also, we found that 50% of the policy makers know about the cost of solar and wind technology. Also, most of them know the potential of these renewable energies in Bahrain. They realized as well the adverse effects of CO_2 emission from the use of oil and gas. All policy makers understand how easy to connect the electricity obtained from the sun and wind systems, which is installed (integrated) in the building, to the national electricity grid. However, only third of them know that 15–30% of electricity consumption can be produced by BIPV.

The most important reasons, according to the decision and policy makers in Bahrain—justifying why solar and wind energy are not forced to be integrated in buildings—are:

(a) Low cost of current electricity.
(b) Availability of oil and natural gas.
(c) Solar and wind electricity are more economic if they are to be used for rural areas, while most buildings in Bahrain are close to the national grid facility.
(d) Lack of experience and knowledge of local engineers and technicians in solar and wind technology (installation and maintenance).
(e) Absence of the awareness of public, and investors, of the advantages of using solar or wind energy, especially when dealing with the cost of kWh as well as cost of each Watt from solar and wind electricity. Its difficult to put legislation without educate, enlight, propagate, and create awareness among the public, otherwise a strong protest may emerge because of financial pressure which may be used by politicians for achieving certain interest.
(f) No taxation system in Bahrain, especially in electricity consumption and its environmental sequences. This makes it harder to offer incentives for sustainable buildings (BIPV and BIWE projects).
(g) Absence of future strategic plans, regulations, legislations, and schemes to encourage the user to opt for sustainable buildings construction.
(h) High initial cost of BIPV (installation, maintenance, and man power).

On the other hand, the results of questionnairing the consultants (architects), had shown that only little possess no knowledge about the potential of solar and wind energy in Bahrain (10–30%). Also, they have little information on the cost of electrical unit (kWh) of solar and wind compared to the conventional electricity (30%). Sixty percent of the architects find it easy to use solar and wind in building (BIPV or BIWE). Eighty percent (80%) of the architects blame all parties (policy makers, contractors, and themselves) for the absence of BIPV in Bahrain. Surprisingly, 80% are interested in BIPV or BIWE projects in Bahrain. Nearly almost the same reasons mentioned by the policy makers for not adopting BIPV projects and legislation, is also said by the architects, except that policy makers are concerned and scared of the pressure may be made by the customers (investors) if they had forced BIPV or BIWE systems to reduce the electricity consumption and, accordingly, the pollution. Also, the consultants had further attributed the absence of BIPV projects to the ignorance of life cycle cost of PV (nearly US$ 300/m^2) and wind turbines systems, the lack of education and knowledge in sustainable design, the political system, the shortage of markets importing sustainable technologies and, finally, the client worries in profitability and pay-back period.

Meanwhile, among the most important results of questionnairing the contractors is that 71% are interested in BIPV projects and 86% are willing to submit a bidding for BIPV or BIWE. Also, 42% find it easy to be involved in BIPV projects while 42% find it not easy and only 16% find it complex to a certain extent. The difficulty of this technology can be overcome by subcontracting (57%).

We also found that 79% of the contractors prefer Design and Build procurement method for conducting BIPV projects. Seventy-two percent (72%) of the contractors are putting the blame on the policy makers for the absence of BIPV projects in Bahrain and 14% put the blame on the architects while 14% put the blame on all (policy makers, architects, and themselves, i.e. the contractors). Indeed 86% of the contractors were wishing to be involved in the Green City project by Euro University in Bahrain, as it will be the first BIPV project in the island. 79% of the contractors are interested in Solar (BIPV) projects than wind (BIWE). The contractors found it important to have a qualified construction manager in BIPV projects (72%), while 14% found it not important, and 14% to a certain extent.

Finally, the contractors (by 86%) are interested in training further their engineers for BIPV projects if free offer or subsided cost is provided to them for this purpose.

During the survey—as many discussions with architects, policy and decision makers, constructors, academics, economist and researchers had been held—there is a large concern about the import of natural gas from Qatar, and also probably from Iran. This means that self-dependence in fuel for energy had been weaken. The government for the past 5 years had made substantial reduction in the cost of electricity unit. Thousands of families has been freed from paying there bills. Last year, the government had waived out cost of electricity of nearly equal to £10 million! Also large, medium, and small industries are lucky to receive reduction on the cost of natural gas for energy production. This is to encourage investment and to create more diversity of the income to the Gross National Product or Gross Development Product.

In fact, to achieve long-term energy independence, i.e. sustainable development, we must have a sustainable construction. This can only be achieved if Bahrain made transition to a new energy paradigm, which is based on sustainable resources. Of the available renewable energy, only solar energy has the capacity to meet large part of Bahrain energy demand.

Two technologies are used to generate solar electricity: direct solar conversion, using PV cells and Concentrating Solar Power (CSP). These two technologies are suitable to overcome the two peaks of electricity consumption in buildings in Bahrain (one at 3 pm and the other at 11 pm during our long summer where energy is mainly used for air-conditioning). The only problem with this technology to be used in Bahrain, according to the survey outcome, is they required large area and waters to clean the mirrors (at least 10 ton of water each week). In fact 90% of Bahrain's area is private land. If the owners lent their land or invested it to install CSP and sell the electricity to the government then all parties (customers, environment, contractors and man power, and owners) will benefit. This can be understood by knowing the following facts, which will highly affect—on a long term—the construction strategy in Bahrain and should lead to the importance of the availability of well dedicated construction management specialists:

(1) Each 1 m^3 of water production cost, internationally, 40–90 pence but its sold for the people in Bahrain for only 4 pence and for industry 43 pence while it cost the government now 21 pence. These prices may change substantially when Bahrain starts to buy natural gas from neighbor countries.
(2) Each barrel of oil has energy equivalent of 6000 million Joule. As each m^2 in Bahrain during summer receive 20 E Joule (10^{18} J), this mean that Bahrain's land receive daily an energy equivalent to that librated from 3 million barrel of oil! Solar is source for electricity and water.
(3) The coast of each kWh, internationally, is 3–6 pence. The citizen in Bahrain pays only (for the first 2000 kWh) 0.5 pence. Knowing that each kWh from conventional power station emits 700 g of CO_2. Therefore, the more electricity consumption from such power station means more damaging to the atmosphere. The cheaper the more expected pollution. As the average income of citizens is not high—bearing in mind the harsh weather in Bahrain for 7 month a year—then the only solution is to use Hybrid power plants, i.e. half of the energy is solar-generated, while the other half comes from conventional fossil fuels.
(4) Bahrain produces 70 million gallons of distilled water each day (nearly 310,000 m^3). Knowing that each m^3 of distilled water requires 4.5 kWh, and knowing that each kWh from conventional PowerStation emits 700 g of CO_2, this means that each day 1400 ton of CO_2 is emitted to Bahrain sky. Therefore CSP systems can be used to provide electricity to produce water with minimal pollution.
(5) Each cooling Tone consume 1.25–1.5 kWh, therefore a conventional 2 ton window type air-conditioner (common) would be equivalent to emitting nearly 2 kg of CO_2 in the atmosphere when operated for 1 h! which mean each day 48 kg of CO_2. If the number of houses in Bahrain is 100,000 and each house has 4 air-conditioners working 24 h then the total daily emission from CO_2 will be nearly 20 million kg. This clearly justify why the CO_2 per capita in Bahrain (and the Gulf Countries GGC) is so high. People are forced to use air-conditioners to avoid the heat fatigue and heat stresses. One should add the emission of CO_2 as a result of producing distilled water; otherwise people will suffer thirst and drink salty water. These countries are known internationally among the poorest in natural water resource. They are in the absolute water scarcity (less than 100 m^3 per capita per year).
(6) The annual electricity consumption in Bahrain is nearly 1600 MW–38 GWh. In fact 60% of this electricity is for domestic use (mainly cooling in summer). This means we use 22,000 MWh for air-conditioning the houses and buildings. This in fact equal to emitting 16,000 ton of CO_2 in our atmosphere. Therefore, solar cooling is the best option for the area.
(7) It is well known that solar energy technology is economically effective if the average solar potential is larger than 4.5 kWh/m^2. In Bahrain, the average is 6 kWh/m^2, which is larger than the average by 33%.

The temperature in the center of the city is found to be more than the rural areas by 25%. This is because of the reflection of the heat wave from building to another (especially from highly glass glazed building with reflective windows). Also, the heat absorption from the concrete, walls, road (asphalt), and heat emitted from air-conditioner [16–18]. Surely, putting PV as glazing (on top of windows or the roofs will reduce the heat inside the city).

On the other hand, wind energy, which has the lowest cost of renewable energy, has no great potential as solar. For this technology to be cost effective the annual average wind speed should be more than 7 m/s while in Bahrain is only 5 m/s. This can be overcome by making the hub height of the wind turbine not less than 120 m from the ground. Also wind turbines would also require a large land area.

Rural lands have to be used. More buildings in the urban areas mean more pollution and worse weather condition. According to Lowry and Boubel [18], in comparing the meteorological variable for urban and rural area, the daily temperature minima is 2.5 °C higher in urban compared to rural. The relative humidity in summer in urban areas is 8% lower, the total wind movement is 25% less, solar radiation is 15% less, total precipitation is 10% higher, total cloud cover (all types) is 10% greater, and the frequency of fog (winter) is 100% greater in urban compared to rural.

Therefore, it is more wise if privates who own the lands in the rural areas to build it using solar electricity or at least make invest by installing solar power station (100 MW or more of CSP) in their land and sell the electricity to the government.

The area under the solar trough concentrators is shaded and can be used for planting; especially water will be a by-pass product. From the above facts, it's clear that if each large complex had produces 25% of its needed electricity from solar and wind energy then a substantial reduction of CO_2 emission would be resulted.

We really feel that if policy makers and architects are drawing attention to the importance of solar and wind energy utility in Bahrain and there positive impact to the environment then many projects of large complexes and large commercial buildings will be designed to utilize solar and wind power. The constructors seem to be keen to be involved in such project.

We strongly believe that the existence of knowledgeable, talented and dedicated construction management personalities in Bahrain will surely change the situation and will boost the use of solar and wind energy utility. This will make advantages to the citizen, the government and the environment. It will also create more jobs and make more investments. Many resorts can be made in the desert like medical or health or tourism.

We are very optimistic to see spike of light on the attention of investors to utilize the solar and wind energy in Bahrain. Two good projects are coming. These are the followings:

(a) The Bahrain World Trade centre, where three wind turbine at three different heights will harness the wind to produce around 0.67 MW (Fig. 1)—to be completed in late 2006.

Fig. 1. The Bahrain World Trade Centre. The total built-up area 120,000 m^2; Twin Towers-240 m height; 45 useable floors and a shopping mall.

Fig. 2. The Green City at Euro University, Kingdom of Bahrain. The Green City will have its own desalination and power plants using solar energy, waste water treatment plant, and sewerage system based on pressurised air and suction technology.

(b) The Green City at the Euro University in Bahrain where PV will be used to power probably 10–20% of the campus (Fig. 2) in a feasible study stage.

According to the Earth trend report (http://earthtrends.wri.org), the per capita of CO_2 in Bahrain, unfortunately, is increasing substantially. In 1950 it was 12,000 ton of CO_2 emission, shifted to 20,000 ton in 1975 and shifted to nearly 32,000 ton in 1998. These are very scary figures.

The total emission of CO_2 in Bahrain in 1998 was 18,687 thousand of tons, which increases by 60%, compared to 1990 level. This makes it 0.1% of the global CO_2 emission. The CO_2 emission in 1999 comes from public electricity, heat production, auto products (5 million tons), other energy industry (4 million tons), manufacturing industries and construction (4 million tons), transportation (1 million tons) and others (1 million tons). This make a total of 15 million tons. The non CO_2 air pollution was also high. The Sulfur dioxide emission was 35,000 ton, the nitrogen oxide was 42,000 ton, carbon mono-oxide was 143,000 and the non-methane Volatile Organic Compound (VOC) was 84,000 ton.

The above figures indicate the high efforts of the Bahraini policy and decision makers toward assuring that electricity and water is available, at a low cost, in all parts of the Kingdom of Bahrain. The government, and the leaders, in Bahrain are aware of the environmental issues, as Bahrain joined Kyoto protocol in 1995. The lack of natural water resource (only 200 m^3 per capita, while the absolute water scarce level is 500 m^3 per capita) and the harsh climate (very humid, 80%, in summer and warm, 32 °C, with annual solar intensity level of nearly 500 W/m^2 [19]).

Electricity is demanded for domestic use mainly for air-conditioning and refrigerating (nearly 80%) [10], especially the buildings are completely energy inefficient.

Unfortunately, many architects and contractors continue to practice their design as if the Sun did not exist. The survey clearly shows the reasons. No much knowledge is possessed by those about how solar and wind technology can be easily adopted in Bahrain. Sustainable development is building for all time through Sun-responsive design. Here, the policy makers, architects, and contractors should attempt to convert occupants to the environments.

Therefore, one should attempt to stay cool in a hot climate with a minimum of energy use. One should engage in building houses in a way overcoming the energy-greedy style. Governments, administrators and citizens, as well as contractors should now know what they might reasonably require as standards for the construction of new buildings, as well as for the renovation of existing ones. This can be made using different guides [20].

The daily and seasonal cycle that the sun gives to Earth, repeated over and over the years, present a far more interesting design and construction challenge. A vital building must be responsive to the cycle of time. A good example is Solaire Dawns building on Lower Manhattan [21]. It was completed in August 2003 with cost of USD 120 million, stands 27 stories tall, and has 293 apartments and 385,000 ft^2. The façade boasts 1300 ft^2 of custom Dupont Tedlar/glass-laminated solar PV modules. In UK, a park Lane College in Leeds had incorporated 472 m^2 of BP PowerGlaz which meets 15% of the building energy. It cost £6.9 million as well as installing 105 kW BIPV at the Warwickshire County Council. The PV panels were installed on the south facing façade of the building with Kalzip construction system housing 573 solar panels on either side of the East and West facing roof. It will produce 68,700 kWh which is equivalent to electricity consumption of 23 typical UK houses—as mentioned in Refocus Magazine, May/June, p. 10. PV can be also integrated in a football stadium and then connected to the grid. 140 MW of solar electricity could generate 280 million kWh annually in sunny regions (like Bahrain)-enough to ensure the basic needs of 2.8 million household in temperate weather and 1 million household in warm regions. Our study shows clearly that the contractors and architects in Bahrain have no problem in doing such work if policy makers decided to go for sustainable building.

In the Arab world, recently Jordon, through The National Renewable Energy Council, are to start a Solar Concentrator Power plant (Central Tower Technology) with 100 MW for one of the resorts (private sector). Egypt is to install, in collaboration with USA, a 150 MW SCP plant. Yemen and Libya are in their way to use the CSP. They had signed the Global Market Initiative for the CSP.

From the above one will understand the reason of emerging of many books on sustainable construction and architectural design [3,22–26].

We personally, had attempted to draw the attention of the public to utilize the solar and wind technology. We had taken the Bahrain International Circuit, which host each year (April) the Formula 1 car race as an example. This circuit uses 4.5 MW during the 3-days function while the rest of the year consumes 2.5 MW. The circuit is in the middle of the desert. Solar and wind power can be integrated to its buildings to generate electricity and produce water [27].

Our goal from this study is to double the wealth and halving the resource use. This can be made only by using the natural sustainable resources and the rural arid large private lands in Bahrain, under a wise leadership from qualified construction managers who can mitigate between the policy makers, architects and contractors. This is a new theory which was proposed recently and is called Factor Four [28].

In fact, sustainable construction focuses on green building. It applies to large commercial as well as institutional buildings. One should really realize the ecological and economic benefits of green building [29]. Furthermore, innovation in construction should always exist [30]. In any project one must address the environmental impact of construction, the sustainable civil engineering, including sustaining resources, controlling or coping with environmental change, and developing sustainable civil engineering [31].

Nowadays, with the enforcement of Kyoto protocol in February 2005, designers of built environments must focus more on green and sustainable construction. They should learn much from the field of industrial ecology. Industrial ecology provides a sound means of systemizing the various ideas which come under the banner of a sustainable construction [32].

We fully agree with the OEAC report [3] that public construction procurement should be more directed towards "greener or sustainable buildings". In most of the countries, construction procurement by government accounts for a considerable proportion of construction investment, and the introduction of a greener public purchasing strategy could have a great impact on environmental performance of a building sector.

Bahrain should establish a target for achieving sustainable building. USA for example is looking for grid-connected solar roof top PV in 2010 to be 2900 MW, if the industry can achieve a breakthrough price of US$2–2.5 per installed PV Watt. In 2004 US had installed PV less than 90 MW and the price per Watt averaged about US$6.5–9. Since most of the electricity (45–60%) goes to building then this mean that a substantial reduction in CO_2 emission will be resulted as each kWh of output of conventional power station emits nearly 0.5 kg of CO_2. The expected price of PV panels is expected to come down to less than US$1 by 2010 [33]. China, on the other hand, plans to increase its renewable energy capacity to 60 GW by 2020.

We had looked into the issue of the relation between the climate, environment and construction in Bahrain. The reasons of why public, industry and government are not designing and constructing buildings that make advantage of the natural, clean and renewable resources, or stay comfort, efficient with minimum energy use and protecting the environment from hazards emissions, is a big issue and requires further socio-economic investigation. We need building regulation that will lead to long-played central role in improving energy efficiency. Construction management can play a vital role in this issue.

6. Conclusion

Our study reveals that policy and decision makers in Bahrain are welling to take action and set legislation for sustainable buildings. However, they are concerned about the possible negative reaction from investors as they do not have adequate knowledge and awareness of the positive impact of BIPV and BIWE on the long-term. Contractors and architects in Bahrain are also keen and welling to be involved in sustainable buildings project. They both need more knowledge and training in BIVP or BIWE installation. Unfortunately, their knowledge on the cost and characteristic of PV or wind energy was found relatively old.

Policy makers, on the other hand, are scare from public reaction if they put certain legislation (such as environmental taxation for large electricity consumption building, large building code, incentives and punishments, etc.) so that customers opt for sustainable building, although they are very enthusiastic in sustainable building because of its positive input to the people themselves and the environment. The public is not much aware of how solar and wind energy could meet major electricity demand, especially for cooling during harsh long summer.

The public, in view of the policy makers, are not welling to bear any extra charge for each kWh of electricity. They want the government only to bear any subsequent cost. It's clear that no development can be made if the oil and gas are sold cheaply for consumers, and subsequently the electricity unit (3 fils for each kWh = 0.4 pence per kWh for the first 3000 units).

Among the main constrains that architects are not publicizing BIVP or BIWE is the high initial cost of PV and wind turbines, the worry about profitability, pay-back period, lack of knowledge, ignorance of the lifecycle cost, and absence of market for PV and Wind as well as their maintenance. This can be achieved by offering special training workshop on BIPV or BIWE, probably twice a year, as well as organizing annual exhibition on solar and wind energy technology for sustainable building designs. Academics and researcher in Bahrain may participate in such issue. They should use all media to make the advantage of BIPV and BIWE to Bahrain. This surely will make pressure on government and people and compromise between them.

Most important, the study reveals that Design and Build methodology in taking sustainable building projects is the most effective procurement method in Bahrain. This is due to the need of local contractors to joint-venture with leading firms in the field of utilizing PV and wind energy for large commercial buildings, especially this technology is relatively complex .This would encourage the contractors to be fully in charge on such projects (design and constructing).

It is that sustainable buildings concept and activity can be only achieved by political decision-making based upon a public awareness that certain, perhaps unpopular, measures should be taken now in order to prevent worse problems in the future. Construction managers of course play a crucial role in defining the problems and in finding ways into the future.

Appendix A

A.1. For the consultants (Architects)

(1) What's the average annual wind speed in Bahrain?
(A) 2 m/s (10%) (B) 3 m/s (10%)
✓ (C) 5 m/s (30%) (D) Do not know (50%)

(2) What's, nearly, the average annual solar radiation in Bahrain?
(A) 200 W/m^2 (10%) (B) 300 W/m^2 (0%)
✓ (C) 500 W/m^2 (30%) (D) Do not know (60%)
(3) What's the efficiency of the PV panels, nowadays, when installed in the site?
(A) 6% (0%) ✓ (B) 15% (30%) (C) 25% (0%) (D) Do not know (70%)
(4) What would be, roughly, the cost of each kWh from PV if installed in Bahrain?
(A) 400 fils (30%) (B) 800 fils (10%)
✓ (C) 1000 fils (0%) (D) Do not know (60%)
(5) Do you find that using solar and wind technologies in big projects are an obstacle to the quality of design?
(A) Yes (0%) (B) No (60%) (C) To a certain extent (40%)
(6) What's the best direction of solar panel when to be installed to houses to produce electricity or heat?
(A) North (0%) ✓ (B) South (70%) (C) East (10%) (D) West (20%)
(7) To generate electricity from the sun one can only do this by using:
(A) PV technology (10%)
(B) Solar thermal only such as solar concentrator power (CSP) (10%)
(C) Both A and B ✓ (80%)
(8) What's the percentage of the direct solar radiation to the total solar radiation in Bahrain?
(A) 30% (0%) (B) 50% (0%)
✓ (C) 70% (60%) (D) Do not know (40%)
(9) Whom do you blame for the absence of utilizing the solar and wind energy in Bahrain?
(A) The architect only (0%) (B) The policy and decision makers only (20%)
(C) The contractor only (0%) (D) All of them (80%)
(10) Electricity can be produced either by solar or wind power. Which one is more attractive to you?
(A) Solar (80%) (B) Wind (20%)
(11) Are you, personally, interested in executing a project for the government or private sector in the kingdom of Bahrain which is, heavily, incorporating the use of solar and wind energy?
(A) Yes (80%) (B) No (0%) (C) To a certain extent (20%)
(12) Please write 4 important reasons justifying why large constructions in Bahrain do not utilize the solar and wind energy?
(A)
……………………………………………………………………………………
(B)
……………………………………………………………………………………
(C)
……………………………………………………………………………………
(D)
……………………………………………………………………………………
Thank you

A.2. For the policy and decision makers

(1) What's the average annual wind speed in Bahrain?
(A) 2 m/s (B) 3 m/s ✓ (C) 5 m/s (67%) (D) Do not know (33%)
(2) What's, nearly, the average annual solar radiation in Bahrain?
(A) 200 W/m^2 (B) 300 W/m^2 ✓ (C) 500 W/m^2 (50%) (D) Do not know (50%)
(3) What would be, roughly, the cost of each kWh from PV if installed in Bahrain?
✓ (A) 400 fils (50%) (B) 800 fils (33%) (C) 1000 fils (D) Do not know (17%)
(4) What's the cost of each electrical Watt from the PV?
(A) 2 USD (33%) ✓ (B) 10 USD (50%) (C) 30 USD (D) Do not know (17%)
(5) Solar energy can be used for cooling, this, in term; will reduce the CO_2 emission very substantially in Bahrain. The reason is that each normal air-conditioner unit (AC), when operated for an hour, is equivalent to emitting:
(A) 50 grams of CO_2 ✓ (B) 1.5 kg of CO_2 (67%)
(C) 4 kg of CO_2 (D) Do not know (33%)
(6) To generate electricity from the sun one can only do this by using:
(A) PV technology (17%)

(B) Solar thermal only such as solar concentrator power (CSP) (33%)
(C) Both A and B ✓ (50%)
(D) Do not know
(7) Do you feel that its important now, especially after the shortage of conventional resources (oil and gas) as well as the implementation of Kyoto protocol, is to integrate solar and wind electricity in large buildings?
(A) Yes (100%) (B) No (C) To a certain extent
(8) The power generated from the PV systems can be converted easily from DC to AC
✓(A) Yes (100%) (B) No
(9) The electricity from solar or wind energy can be connected to the national grid. This can be very easily done in Bahrain:
✓(A) Yes (100%) (B) No
(10) Solar and wind energy is more suitable for rural areas than urban areas:
✓(A) Yes (100%) (B) No
(11) If each large complex and sky scraper in Bahrain uses its roof and window to install a PV panels to generate electricity, then we can save, roughly, electricity from the grid by:
(A) 5–15% (33%) ✓ (B) 15–30% (33%)
(C) 30–50% (33%) (D) Do not know
(12) Please write 4 important reasons justifying why large governmental constructions in Bahrain do not utilize the solar and wind energy?
(A)
………………………………………………………………………………………
(B)
………………………………………………………………………………………
(C)
………………………………………………………………………………………
(D)
………………………………………………………………………………………
Thank you

A.3. For the contractors

(1) Are you, personally, interested in executing a project for the government or private sector in the kingdom of Bahrain which is, heavily, incorporating the use of solar and wind energy?
(A) Yes (71%) (B) No (7%) (C) To a certain extent (22%)
(2) If there is a tender for a construction in Bahrain that's uses solar and wind energy for electricity production, will you submit your bidding?
(A) Yes (86%) (B) No (14%)
(3) Would you find it difficult to conduct a project for installing solar and wind energy to produce electricity in Sky Scrapers or large size complexes?
(A) Yes (42%) (B) No (42%) (C) To a certain extent (16%)
(4) Would it be easy for you to subcontract with a company that can do the part related to solar electricity a construction or a building in Bahrain?
(A) Yes (57%) (B) No (14%) (C) To a certain extent (29%)
(5) What method of procurement is recommended for implementing solar and wind technology in construction in Bahrain?
(A) Design & Build (79%) (B) Construction management (21%)
(6) Whom do you blame for the absence of utilizing the solar and wind energy in Bahrain?
(A) The architect only (14%) (B) The policy and decision makers only (71%)
(C) The contractor only (D) All of them (14%)
(7) Do you think that you can make more profit if you get involved in solar and wind energy utilization projects in Bahrain for electricity production?
(A) Yes (14%) (B) No (43%) (C) To a certain extent (43%)
(8) It was announced recently that the *European University* is constructing a *Green City*, where the electricity may be produced by using *Solar Power*. Would it be a wish for you to win the bid of constructing this environmentally friendly project?
(A) Yes (93%) (B) No (7%)

(9) Are you interested in training your engineers and technicians in how to use solar and energy for electricity production—if the training cost is reasonable?
(A) Yes (86%) (B) No (14%)
(10) If there is a free offer, or subsidized cost, for the education for yourself and your staff to attend workshops in installing solar energy systems in buildings, then would you attend it?
(A) Yes (76%) (B) No (C) Depends on the trainee (21%)
(11) Electricity can be produced either by solar or wind power. Which one is more attractive to you?
(A) Solar (79%) (B) Wind (21%)
(12) Do you find the existence of a construction manager is very important in these types of projects since design issues are complicated?
(A) Yes (72%) (B) No (14%) (C) To a certain extent (14%)
Thank you

Appendix B

(i) **Decision and policy makers**:

- The Royal Court
(Dr. Basel M. Abul Fatih; Director, Projects & Maintenance)
- Council Of Representatives
(HE Mr Khalifa Al-Dhahrani, the Chairman)
- Council of Consultative (Shura)
(HE Dr Faisal Al-Musawi, the Chairman)
- Ministry Of Electricity & Water
(Dr Abdul Majeed Alawadhi, the Undersecretary)
- Ministry Of Housing & Works
(Eng. Nayef Al-Kalali, the Undersecretary)
- Ministry Of Municipality
(Dr Jumaa Al Kaabi, the Undersecretary)

(ii) **Architectural consultants**:	(iii) **Contractors**:
• Gulf House Engineering	• CEBARCO
• ATKINS	• Zachariades
• GEMAC	• Dadhabai
• MSCE	• CHAPO
• Mazen Al Umran	• NASS
• Watson Khonji	• Project SA
• Ahmed Janahi	• M. Jalal Kontra
• Dhia Tawfeeki	• Bokhowa Group
• Municipality	• Haji Hassan Alali
• The Modern Architect	• Ahmed Mansoor Alali
	• Al Dhahrani
	• Kamashki
	• Almoayed
	• Al Hamad Construction & Development

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