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Energy Management Application in Construction Projects in the Gaza Strip, Palestine

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Abstract: This study explores the energy management criteria that local contracting firms operating in the Gaza Strip apply in construction processes. To achieve the objective of this study, a comprehensive review of the literature was conducted to identify the energy management application criteria followed by a structured questionnaire survey. The study showed that contracting organisations in the Gaza Strip do not strictly apply energy management to their projects, as many of these organisations have not considered energy issues seriously. The results showed that energy issues are not a predominant consideration of clients when the conditions and specifications for conventional local construction projects are being prepared. The findings of the survey provide useful knowledge to contractors and project managers in energy management requirements in order manage energy on construction projects. This study takes a novel perspective in the subject area as it is considered the first study to investigate energy management aspects in the local construction industry. The findings of this study will be valuable to construction practitioners in terms of saving energy and promote sustainable construction. Although this study is specific to Palestine, its results can be applicable to other developing countries. It is recommended to expand this study using qualitative method and involving other construction parties.

Keywords: Energy, Management, Application, Construction, Environment

INTRODUCTION

In Palestine, the construction sector has been crucial in extending job opportunities in the Palestinian labour force (Enshassi et al., 2007). The Palestinian Central Bureau of Statistics (PCBS) indicated that 15.6% individuals working on the West Bank and Gaza Strip were employed in construction. In 2013, the construction industry contributed 14.1% to the Palestinian Gross Domestic Product (GDP) (PCBS, 2016). The sector also indirectly employs approximately 30% of labourers in industries related to the construction sector and other services and productive sectors (Palestinian Contractors Union [PCU], 2006). The construction sector is considered as one of the most important sectors of industries to the Palestinian economy and plays a major role in the development of infrastructure facilities. Construction can be used as a vehicle to erect schemes to protect the environment (Enshassi, Mohamed and Abushaban, 2009; Enshassi, Al-Najjar and Kumaraswamy, 2009). However, environmental issues are seldom considered in construction projects in Palestine

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due to the emergency nature of the construction projects (Enshassi, Kochendoerfer and Rizqa, 2014).

Countries with fast economic growth require huge amounts of energy. Energy is a crucial factor in economic competitiveness and employment (Abdelaziz, Saidur and Mekhilef, 2011). The energy situation in the Gaza Strip is particularly concerning because it is dependent upon outside countries (i.e., Israel) for most of its electricity and petroleum products (Elaydi, Ibrik and Khoudary, 2012). This dependency has resulted in frequent electricity shortages and high pricing of energy products. The limited nature of the resources and the Palestinian reliance on outside countries has led to limited economic development and the majority of the population has regularly experienced blackouts for two-thirds of the day (Abu Hamed, Flamm and Azraq, 2012; Muhaisen and Ahlbäck, 2012). A number of large-scale construction projects are currently being implemented: however, more will be needed in the future to meet population growth demands. As the scale of the construction projects grows, environmental consequences and energy consumption becomes increasingly significant issues (Enshassi, Kochendoerfer and Al-Ghoul, 2016).

Further, the process of manufacturing and transporting building materials and installing and constructing buildings consumes large amounts of energy and emits a large quantity of greenhouse gases (GHGs) (Enshassi, Ayash and Mohamed, 2018; Muhaisen and Ahlbäck, 2012). A number of studies have been conducted on energy use and GHG emissions in the life cycle of buildings. However, to date, very few studies have focused specifically on the construction stage and none comprehensively (Yan et al., 2010). Energy is needed for a variety of processes, including the transportation of construction materials, tools and equipment from one place to another, drying, drainage and heating, fuelling generators and equipment, as electricity for lighting purposes and to operate machinery. Energy use will affect the final costs of a project. Further, the use of fossil fuel has adverse effects on the environment and human health due to the emissions of GHGs and local air pollutants (United Nations Environment Programme - Sustainable Buildings and Climate Initiative [UNEP-SBCI], 2009). Thus, energy management constitutes a strategic area for cost reduction and environmental protection.

A large part of the energy used in construction process is related to the use of mechanical plants for transporting, levelling, digging, lifting, compacting and mixing. A second significant component relates to the energy used in buildings, both temporary and permanent, by builders in construction activities (Enshassi, Ayash and Mohamed, 2018). Energy required in the construction process can be divided into two main categories, fossil fuel and electricity. Fuel is used in transport and in the equipment onsite, mostly as diesel. With the transport of people, petrol is also used. On the construction site the quantity of diesel and electricity used are depend on a couple of factors like the type of project, the size of the project, the availability of electricity and construction method (Gorkum, 2010). The major fuel used on construction sites is diesel with percentage of fuel consumption was between 75% and 80%. Electricity can be supplied from temporary main supplies and mostly from diesel generators. When the numbers and types of the plant equipment are taken into account, these electrical consumption figures represent only 20% to 25% of the total energy consumed on construction site. The major consumption of energy on site are construction plants such as backhoe loaders, dampers, hydraulic excavators, cranes, etc. (Ndayiragije, 2006). Lack of national energy resources makes the energy sector in Palestinian territories to be almost dependent on imported energy supplies, specifically electricity and oil products. Because of political and logistical factors, nearly all of these supplies at present come from Israel (World Bank, 2007). In Palestine, there are no studies that focused on energy management on the life cycle of construction projects. Therefore, this paper sought to explore local contracting firms' applications of energy management criteria during construction processes in the Gaza Strip.

ENERGY MANAGEMENT

Energy management has been defined as "the strategy of adjusting and optimising energy, using systems and procedures so as to reduce energy requirements per unit of output while holding constant or reducing total costs of producing the output from these systems" (Asian Productivity Organization [APO], 2008). Abdelaziz, Saidur and Mekhilef (2011) stated that "energy management is the strategy of meeting energy demand when and where it is needed". Capehart, Turner and Kennedy (2003) alternately defined energy management as "the continuous, systematic and well-organised audit of energy consumption, aiming at energy cost optimisation with respect to energy demands, user characteristics, funding opportunities, financing ability and emission reductions achieved". The Carbon Trust (2011) defined energy management as "the systematic use of management and technology to improve the energy performance of an organisation" that is considered the most comprehensive definition of energy management. Changing how energy is managed by implementing a wide energy management programme is one of the most successful and cost effective ways of bringing about energy efficiency improvements (Abdelaziz, Saidur and Mekhilef, 2011). It is also an important tool in helping organisations meet the objectives critical to their short-term survival and long-term success (Turner and Doty, 2009).

Energy management is now in the global spotlight due to the pressing need to save energy and reduce GHG emissions worldwide. It is inspired by and similar to other management systems such as environmental management, health and safety management and quality and production management (Christoffersen, Larsen and Togeby, 2006). There are various definitions of energy management, however, each definition has the same objective and seeks to achieve the same task: to lower energy use without sacrificing the quality of the environment and/or products through the employment of capital, technology and management skills (Al-Homoud, 2000). An energy management system is a collection of processes, procedures and tools designed to engage staff at all levels within an organisation to manage energy use on an on-going basis (Global Superior Energy Performance Partnership - Energy Management Working Group [GSEP-EMWG], 2013). Energy management is a dynamic process under which new ideas and knowledge can be generated to produce additional energy efficiency gains (Kannan and Boie, 2003). Energy management is considered a combination of energy efficiency activities, techniques and the management of related processes that result in lower energy costs and carbon dioxide emissions (Kannan and Boie, 2003). Energy management processes aim to minimise energy costs/waste without affecting production and quality and minimise environmental effects (Bureau of Energy Efficiency, 2010; Goldberg, Reinaud and Taylor, 2011).

Russell (2005) argued that energy efficiency refers to practices and standards set forth in an energy management plan. Despite the high level of total energy consumption by industrial small and medium sized enterprises (SMEs), the issue of energy efficiency improvements in SMEs has received little attention to date. Construction contractors and subcontractors can have a major impact on the energy efficiency of a building's construction and energy management can help to control energy consumption and reduce unnecessary expenditures and save money (Russell, 2005). Energy management improves cost effectiveness of construction operation and working conditions, protects the environment and prolongs the useful life of equipment and fuels (Ndayiragije, 2006). Significant endeavours have been undertaken to address increases in energy consumption and reduce harmful climate impacts: for example, the United Nations (UN) issued the Kyoto Protocol and the Copenhagen agreement under which "energy saves" and "low carbon economy" are mandatory. Further, moral initiatives have been implemented around the world to address increases in energy consumption and related GHG emissions (Chuanzhong and Yingji, 2011). Most countries consider the energy issue to be serious and have introduced policies, including measures to improve energy efficiency, to reduce energy consumption and GHG emissions (UNEP-SBCI, 2009). Given the increasing demand for energy, especially electricity, across all sectors, a more efficient use of energy must be considered as a major option to ensure global sustainable development in the 21st century (Akinbami and Lawal, 2009).

Construction energy (one component of embodied energy) forms a single aspect of project direct energy. Embodied energy is the energy consumed in all activities necessary to support a process. It comprises a direct and an indirect component (Dixit et al., 2012). For building construction, the direct energy includes the fuels used directly for the assembly of the building while the indirect energy includes the energy embodied directly in inputs to the construction process, and the energy embodied directly in inputs to those processes (Treloa, 1998). Construction energy refers to the energy consumed during the installation of materials (until the practical completion of a project) and represents the largest share of carbon dioxide emissions in the construction process (Davies, Emmitt and Firth, 2013). During project construction, contractors use energy whenever construction materials are moved from one place to another, to transport materials from manufacturers to building sites and in a variety of processes during the erection of the building (e.g., as electricity to provide light and operate machinery and for drying and drainage) (Adalberth, 1997). The production phase of construction (an important phase of any construction project) accounts for approximately 5%–10% of the total energy consumption during production processes (UNEP-SBCI, 2009). Carbon dioxide emissions that are the result of using energy during construction activities need to be considered (Saravanan, 2011). Previous studies have shown that onsite construction can represent up to 7% of a project's life cycle energy, depending on the building type and lifespan (Davies, Emmitt and Firth, 2013). United Nations Centre for Human Settlements (UNCHS) (1991) indicated that construction activity accounts for a small, but important proportion of the embodied energy in buildings (i.e., 15%–30%). Building material manufacturing requires the greatest use of embodied energy (i.e., 90%), while transportation and construction require 4% and 6% of embodied energy, respectively (Chang and Ries, 2011).

During onsite construction, contractors often given the authority to choose which technologies and equipment to employ. When selecting a construction method for a project, the deciding factors most often comprise constructability, construction time, location, available resources and finance. The amount of energy used for each construction method and the emission of specific carbon dioxide are not factors of great importance in selecting a construction method (Gorkum, 2010). Recently, many contractors have shown a vested interest in embodied energy performance due to their significant involvement within project procurement, pre-construction and on site construction activities (Davies et al., 2013). Contractors also play an important role in promoting sustainable development within the construction industry and must assume the responsibility or minimising the negative impact on the environment and society and maximise the economic contribution (Tan, Shen and Yao, 2011). With their positive net present value and rapid payback rate, energy saving building technologies represents the best available options for reducing GHG emissions (Davies et al., 2013).

Energy production/trade is considered as one aspect of the "energy tragedy" in Palestinian territories and energy consumption the other. Palestinian territories mostly rely on Israel for their fossil fuel and electricity imports (Abu Hamed, Flamm and Azraq, 2012). In Palestine, energy is even more important due to the critical situation represented by the country's high population density, lack of natural resources and unstable political situation (United Nations Office for the Coordination of Humanitarian Affairs [OCHA], 2008). Palestine's use of energy and energy conservation in its domestic and industrial sectors are no better than most developing countries (Yaseen, 2008; Ministry of Planning and Administrative Development [MoPAD], 2012). Energy security is the main challenge facing the energy sector in Palestinian territories due to the territories' high dependency on Israeli sources for energy (MoPAD, 2012). Conventional construction methods used in Gaza consume large amounts of energy and materials and generate vast amounts of waste. Combined with the rapid population growth in Gaza, the current approach to construction will inevitably increase demands for these resources to unsustainable levels, while also causing the degradation of Gaza's vulnerable environment (Muhaisen and Ahlbäck, 2012).

RESEARCH METHODOLOGY

Population and Sampling

The population for this research comprised all first class, second and third construction contracting companies working in the Gaza Strip that held valid registration according to the PCU records. Experienced projects managers and site engineers working for the contracting companies in Gaza Strip were chosen as the sample of this study (i.e., respondents), as they are responsible for making decisions in relation to corporate and project objectives. The projects managers and site engineers included individuals experienced in management and construction activities, had the highest authority to handle day-to-day activities and were accountable for managing energy on sites.

The following formula was used to determine the sample size of the unlimited population (de Vaus, 2002; Creative Research System, 2014) for this study:

$$SS = \frac{Z^2 \times P \times (1 - P)}{C^2}$$

Sample size (SS) referred to the number of respondents needed be included in the study. In this study, it represented the number of the contracting companies that needed to be surveyed. One individual (i.e., a project manager or site engineer) was selected from each company to complete the questionnaire.

Z-value (*Z*) referred to the *Z* statistic for a level of confidence and equalled 1.96 for a 95% confidence level.

Percentage picking a choice, "degree of variability" (*P*) was the degree of variability in the attributes being measured and referred to the distribution of attributes in the population that explained the estimated proportion of an attribute present in the population (Czaja and Blair, 1996). The sample size was computed using $P = 0.5$, expressed as decimal.

Confidence interval (*C*) error was the range in which the true value of the population was estimated and expressed as a decimal (Israel, 2013). A confidence interval (*C*) of 8% was assumed for this study to calculate the sample size (Bartlet, Kotrlik and Higgins, 2001).

Thus, the sample size for this study was calculated as follows:

$$SS = \frac{1.96^2 \times 0.5 \times (1 - 0.5)}{0.08^2} = 150 \qquad \text{Eq. 1}$$

It was determined that the above sample size formula would be valid if the calculated sample size was smaller than or equal to 5% of the population size ($n/N \leq 0.05$). If this proportion were larger than 5% ($n/N > 0.05$), the following formula would need to be used for finite population correction (Bartlet, Kotrlik and Higgins, 2001; Naing, Winn and Rusli, 2006):

$$\text{New SS} = \frac{SS}{1 + \frac{SS - 1}{pop}}$$

where "New SS" referred to the corrected sample size and the pop (i.e., population size) was 179.

In this study, the population size was 179 and the ratio between the obtained sample size and the population equalled 0.84 (150/179) (a figure larger than 0.05). Thus, the corrected sample size for the finite population was calculated as:

$$\text{New SS} = \frac{150}{1 + \frac{150 - 1}{179}} = 82 \qquad \text{Eq. 2}$$

Survey

A questionnaire survey was employed in this study. The questionnaire consists of two parts. The first part of the questionnaire comprised eight questions designed to collect industry information and general information on the demographics of the respondents. The second part of the questionnaire comprised 17 energy management requirement statements. The respondents were asked to evaluate their company's adoption of energy management requirements in construction projects.

In total, 100 questionnaires were distributed to project managers and site engineers of construction companies working in the Gaza Strip, 86 questionnaires were completed and returned: however, only 76 (76%) questionnaires were deemed valid to be used in the analysis. In the construction enterprises, a good response rate is around 30% (Enshassi, Al-Hallaq and Mohammed, 2006; Enshassi et al., 2007). Therefore, the response rate in this study is acceptable. Additionally, when compared with similar studies (e.g. de Groot, Verhoef and Nijkamp, 2001; Rohdin, Thollander and Solding, 2007; Enshassi, Mohamed and Abdel-Hadi, 2013), the response rate of 76% can be considered acceptable and high. The Likert rating scale is widely used to measure attitudes and requires the participants to select a response in relation to a statement that reflects their particular attitude or opinion (Naoum, 2007). In this study, respondents were asked to indicate their degree of agreement about listed energy management application requirements using a scale of one (i.e., "Never Applied") to five (i.e., "Always Applied"). The energy management application requirements statements were adopted from previous studies (as shown in Table 1).

Table 1. Energy Management Application Requirement

No.	Energy Management Application Requirement	References
1	Have an energy policy	Christoffersen, Larsen and Togeby (2006), United Nations Industrial Development Organization (UNIDO) (2007), Turner and Doty (2009) and Kahlenborn et al. (2010)
2	Having a written energy policy	Ates and Durakbasa (2012)
3	Having an official energy manager	UNIDO (2007), Kahlenborn et al. (2010) and Ates and Durakbasa (2012)
4	Setting an energy saving target	Kannan and Boie (2003), Christoffersen, Larsen and Togeby (2006), The Carbon Trust (2011) and Ates and Durakbasa (2012)
5	Have set quantitative energy saving goals	Christoffersen, Larsen and Togeby (2006)
6	Energy management plan	UNIDO (2007) and Turner and Doty (2009
7	Planning	Kahlenborn et al. (2010) and The Carbon Trust (2011)
8	Creation of an Energy Manual	UNIDO (2007)
9	Have an energy strategy	The Carbon Trust (2011)
10	Identification of key performance indicators, unique to the company	UNIDO (2007) and Kahlenborn et al. (2010)
11	Assess future energy needs	Turner and Doty (2009) and Kahlenborn et al. (2010)
12	Staff training and engagement	Kannan and Boie (2003), Kahlenborn et al. (2010) and The Carbon Trust (2011)

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Table 1. (*continued*)

No.	Energy Management Application Requirement	References
13	Energy audit and accounting	Kannan and Boie (2003) and Turner and Doty (2009)
14	Continuous energy accounting	Kahlenborn et al. (2010)
15	Mapping of energy use	Kahlenborn et al. (2010)
16	Having implemented energy efficiency projects	UNIDO (2007) and Ates and Durakbasa (2012)
17	Analysis of energy historical data	Kannan and Boie (2003), Turner and Doty (2009), Kahlenborn et al. (2010) and The Carbon Trust (2011)
18	Have energy records	Turner and Doty (2009)
19	Monitoring and analysing energy use	The Carbon Trust (2011)
20	Make energy recommendations	Turner and Doty (2009)
21	Periodic reporting of progress	UNIDO (2007)
22	Educating key employees	Kahlenborn et al. (2010)
23	Evaluate program effectiveness	Turner and Doty (2009)
24	Engineering analysis and investments proposals based on feasibility studies	Kannan and Boie (2003)
25	Assessing the compliance with legal obligations	Kahlenborn et al. (2010)
26	Identify outside assistance	Turner and Doty (2009)
27	Energy-efficient purchases	Kahlenborn et al. (2010)

Not all of the collected statements/variables in the initial lists were consistent with the conditions and circumstances surrounding the Gaza Strip (i.e., the economic level, the type of projects, the geographical region and the occupation factors present at the Gaza Strip). Accordingly, the statements selected for the study were amended so that they would be commensurate with the nature of construction projects and problems present in the Gaza Strip. A pilot study using face-to-face interviews were conducted with six experienced project managers who each had more than 20 years' experience in managing local construction projects. The process involved revising and verifying all of the statements/variables collected in the literature review to ensure their appropriateness to the context of the construction industry in the Gaza Strip. The comments received from each expert were reviewed and a number of amendments, including deleting, adding, merging or modifying, were made to the statements to develop the final version of the statements. As a result, 17 drivers were selected from the 27 drivers that were collected for the comprehensive literature review. The researchers delivered the (self-administering) questionnaire in person to the contractors' offices and explained the objective and importance of the research to the contractors and the construction industry in general.

Data Analysis

The 22nd version of Statistical Program for Social Sciences (SPPS) was used for the data analysis. The data obtained from the survey was analysed using mean scores (MS) as an average index together with standard deviation to rank the energy management application requirement. Descriptive statistics were used to describe the main features of the collected data in quantitative terms. Sign test was used to determine if the mean of a paragraph was significantly different from a hypothesised value 3 (middle value of Likert scale). If the *p*-value (Sig.) is smaller than or equal to the level of significance, then the mean of a paragraph was significantly different from a hypothesised value 3. The sign of the test value indicates whether the mean is significantly greater or smaller than hypothesised value 3. On the other hand, if the *p*-value (Sig.) is greater than the level of significance, then the mean a paragraph is insignificantly different from a hypothesised value 3 (Enshassi, Elzebdeh and Mohamed, 2017). The correction coefficient for the questionnaire was less than 0.05. Thus, the questionnaire was valid and measured what it is purported to measure. The Cronbach alpha (α) was calculated as 0.92 which greater than Pallant's (2005) suggested alpha of 0.7. This indicated that the data collected from the questionnaire were interrelated and that the scale was consistent with the sample.

RESULTS AND DISCUSSION

Table 2 shows that 22.4% of the respondents were highly educated and held postgraduate degrees. The respondents had over five years work experience and most of their contracting companies had more than five years' experience in the local construction industry. The majority of the respondents worked for contracting organisations that were either small or medium sized organisations, as the fixed workers ranged between 11 to 50. It should be noted that the local contracting organisations depended on temporary employees: thus, the number of fixed employees did not necessarily indicate a company's size. The local contracting companies also depended on hiring subcontractors to execute the construction projects. The results also showed that the respondents had worked on different types of projects, including, residential and infrastructure projects.

Seventeen representative energy management requirements were found to be significantly and substantially used in current practices to measure energy management application levels in industrial firms and were labelled PEM1 to PEM17, sequentially. Table 3 sets out the results for the MS, standard deviations (SD), *t*-test results, average index indicators and ranks order calculations in relation to the level of application of each proposed requirement of energy management. The MS for the 17 energy management requirements were used to represent a company's level of application of energy management: the higher the score, the higher the organisation's level of energy management application. The application level of each requirement was generated using the average index method, that is, by comparing each requirement MS with the suggested MS ranges to attain the application index (i.e., "Very High" for $4.50 \leq MS \leq 5.00$, "High" for $3.50 \leq MS < 4.50$, "Average" for $2.50 \leq MS < 3.50$, "Low" for $1.50 \leq MS < 2.50$ and "Very Low" for $0.00 \leq MS < 1.50$). Figure 1 provides a graphical presentation of the MS for the application requirements.

Table 2. Respondents' Profile

Information About Respondents	Categories	Frequency	Percentage
Education level	Bachelor	59	77.6%
	Postgraduate studies	17	22.4%
Respondent experience in the construction works	From one to less than three years	3	3.9%
	From three to less than five years	12	15.8%
	From five to less than 10 years	34	44.7%
	More than 10 years	27	35.5%
Company classification class	Third class	16	21.1%
	Second class	30	39.5%
	First class	30	39.5%
Company experience in the construction industry	From one to less than three years	1	1.3%
	From three to less than five years	5	6.6%
	From five to less than 10 years	28	36.8%
	More than 10 years	42	55.3%
Company size (number of employees)	Less than 10 employees	12	15.8%
	From 11 to 30 employees	35	46.1%
	From 31 to 50 employees	25	32.9%
	More than 50 employees	4	5.3%
Types of implemented projects through company in the last 10 years	Residential	32	42.1%
	Infrastructure	34	44.7%
	Public buildings	9	11.8%
	Environmental	1	1.3%
Number of executed projects in the last 10 years	10 projects or less	23	30.3%
	11–20 projects	36	47.4%
	21–30 projects	16	21.1%
	More than 30 projects	1	1.3%

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Table 2. (*continued*)

Information About Respondents	Categories	Frequency	Percentage
Value of executed projects during the last five years (million dollars)	From one to less than two	13	17.1%
	From two to less than five	40	52.6%
	More than five	23	30.3%

One sample *t*-test was undertaken to determine whether or not the respondents considered the proposed energy management application requirements important in measuring the application levels of energy management. The results revealed that all requirement statements had *p*-values less than the significance level of 0.05 and *t*-values greater than the critical *t*-value (1.99). Only one requirement (i.e., PEM1) had a positive *t*-value (+ 2.09), the MS of this requirement was higher than the hypothesised value (3) (refer Table 3) (MS = 3.14). All other requirements (PEM16–PEM17) had negative *t*-values that yielded MS values smaller than the hypothesised value of 3.

Table 3. Respondents' Level of Application of Energy Management

No.	Energy Management Application Requirements	MS	SD	*t*-Value	*p*-Value (Two-Tailed)	Average Index Indicator	Rank
PEM1	My company preparing an environmental management programme for each project.	3.14	0.60	2.09	0.02	Average	1
PEM4	My company conducting energy audit and accounting for its onsite works to record and report energy consumption and saving opportunities.	2.43	0.91	–5.40	0.00	Low	2
PEM3	My company providing a strategy to save onsite energy for each project.	2.38	0.98	–5.50	0.00	Low	3
PEM2	My company presenting onsite energy management as one component of its written policy.	2.30	0.86	–7.03	0.00	Low	4

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Table 3. (*continued*)

No.	**Energy Management Application Requirements**	**MS**	**SD**	***t*-Value**	***p*-Value (Two-Tailed)**	**Average Index Indicator**	**Rank**
PEM7	My company preparing an energy management plan for each project to save onsite energy.	2.18	0.92	–7.73	0.00	Low	5
PEM5	My company establishing an energy saving objectives and targets for all onsite works.	2.14	0.92	–8.11	0.00	Low	6
EM11	My company regularly assessing the compliance and committing to all legal obligations and other regulatory requirements related to energy aspects for onsite works.	1.97	0.86	–10.36	0.00	Low	7
PEM6	My company identifying unique key performance indicators related to onsite energy issues.	1.95	0.86	–10.64	0.00	Low	8
EM10	My company conducting regular assessment of its future energy needs.	1.93	0.82	–11.30	0.00	Low	9
PEM9	My company conducting periodic revision of significant historical data related to energy aspects for onsite works.	1.87	0.81	–12.24	0.00	Low	10
EM13	My company providing the required experienced personnel, as well as technical and financial resources to save energy during on site construction.	1.80	0.75	–13.94	0.00	Low	11

(*continued on next page*)

Table 3. (*continued*)

No.	Energy Management Application Requirements	MS	SD	*t*-Value	*p*-Value (Two-Tailed)	Average Index Indicator	Rank
EM12	My company hiring a specialised committee or person responsible for all energy issues during onsite works.	1.79	0.75	–14.00	0.00	Low	12
PEM8	My company setting a monitoring system for energy use during onsite works.	1.76	0.75	–14.45	0.00	Low	13
EM17	My company providing awareness programmes and tools to save energy during onsite works.	1.72	0.69	–16.24	0.00	Low	14
EM16	My company providing specialised energy management training programmes for its employees.	1.70	0.65	–17.37	0.00	Low	15
EM14	My company introducing incentives for energy saving during onsite construction works.	1.54	0.62	–20.52	0.00	Low	16
PEM15	My company creating and using energy manual to save energy during onsite works.	1.46	0.55	–24.30	0.00	Very low	17
	Overall application requirements.	2.01	0.52	–16.55	0.00	Low	

Notes: MS: Mean score; SD: Standard deviation; Critical *t*-value (two-tailed): at degree of freedom (df) = (N – 1) = (76 – 1) = 75 and significance level 0.05 equals 1.99. The hypothesised population mean is the critical rating at 3.

As shown in the Table 3, the MS value of the application of energy management requirements ranged from 1.46–3.14 and had an overall MS of 2.01. Of the total 17 application requirements, 15 had a low degree of application and one of the remaining two requirements had an average degree of application with the highest application level of the listed requirements and the other requirement has a very low degree of application with the lowest application level. These results showed that the degree of application of the energy management requirements included in the study by the respondents was very low to average. Further, the average MS of the listed requirements equalled ($1.50 \leq$ "Overall MS = 2.01" < 2.50). This data indicated that the overall application level corresponded with the low application indicator category. It is evident from the results that the majority of the local construction contractors were very limited in their applications of energy management requirements to construction projects. Figure 1 illustrates energy management application requirements.

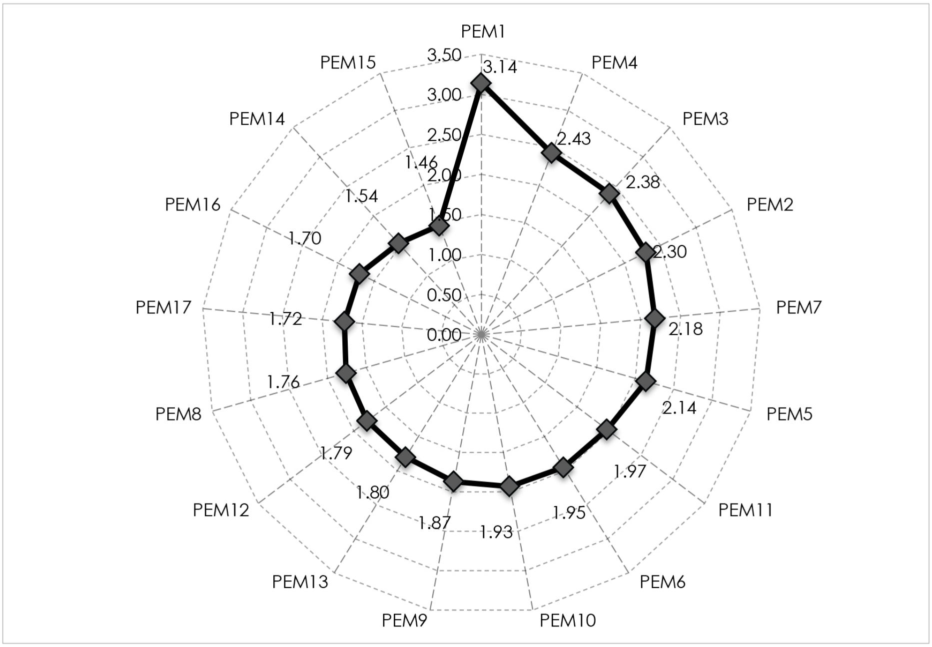

Figure 1. Energy Management Application Requirements (PEM1–PEM17)

The reasons for the current level of implementation can be traced to the following issues. It was clear that the respondents had a moderate level of awareness of energy management benefits, but were lacking in knowledge about the techniques and standards needed to implement the energy management concept. Indeed, this issue was not a priority for respondents and a general lack of urgency surrounded this issue. Further, this issue was not the subject of any publicity that could heighten the contractor managers' interest in the matter. Additionally, energy management application represents an extra cost to local contractors; thus, the respondents had concerns about adopting the concept in their activities. Energy issues are not a predominant consideration of owners/clients when preparing the conditions and specifications for conventional local construction projects. Many constraints impede energy management adoption during project construction, including a lack of support from company management and a lack of awareness by company staff about the importance of energy management in construction. These resulted supported the findings of Kostka, Moslener and Andreas (2013) who observed that only a minority of contractors actively performed energy saving practices at a significant level. These results were also similar to those of Ates and Durakbasa (2012) who found that only 22% of the surveyed industrial companies actually practice energy management in Turkey. Similarly, Christoffersen, Larsen and Togeby (2006) showed that only 3%–14% of industrial Danish firms practice energy management.

The respondents ranked moderately and in first position requirement PEM1 that stated "My company prepares an environmental management program for each project" (MS = 3.14, SD = 0.60 and *p*-value = 0.00). PEM1 lay in the average application indicator category. This result suggests that environmental issues were only moderately considered in practice due to respondents' low environmental awareness levels. Similarly, Majdalani, Ajam and Mezher (2006) observed that Lebanese contracting firms do not enforce many good environmental practices. While Abd Elkhalek, Aziz and Omar (2015) found that 40.6% of Egyptian contractors did not have any stated environmental management policies, objectives and procedures, indicating that environmental management system implementation and adoption in the Egyptian construction industry is very low.

The respondents rated requirement PEM4 "My company conduct(s) energy audit(s) and accounting for its onsite works to record and report energy consumption and saving opportunities" as the second energy management requirement applied by their organisations (MS = 2.43, SD = 0.91 and *p*-value = 0.00). PEM4 lay in the low application category. Despite its low application level, this requirement ranked before other energy management requirements, as local contractors can implement energy accounting and auditing without additional financial costs. Further, energy consumption control and accounting in the local construction sector have been performed in unstructured and informal forms to estimate the energy required to operate the equipment or to realise the energy share of project costs. Generally, the outcome of this energy audit is information used to determine the time and amount of energy required for a project (Kannan and Boie, 2003). These results supported the findings of Thollander et al. (2013) who found that following energy audits, companies begin to adopt other requirements and measures to lower energy use. The low application level of energy audits can be attributed to a low awareness about energy management strategies and techniques.

The requirement that was ranked in the lowest position of the proposed requirements was PEM15 "My company has created and uses an energy manual to save energy during onsite works" (MS = 1.46, SD = 0.55 and *p*-value = 0.00). PEM15 lay very low in the application category. It's very low application indicates that energy manuals are not used in the local construction sector, but some informal guidance was present based on experience. To some extent, this low application in energy management can be attributed to the limited experience and interest of top management local contractors about energy management technologies, strategies and approaches. These results also revealed that none of the studied firms had any specialist personnel assigned to manage energy, as technical employees and middle managers managed most energy issues. The results of the UNIDO (2007) study suggested that energy manuals should be prepared based on previous documented energy saving practices and policies. However, the information on the standards, regulations and practices related to energy management required to develop an energy manual is unavailable in the local construction sector. Thus, it is not surprising that PEM15 was the energy management requirement ranked last by respondents.

CONCLUSION AND RECOMMENDATIONS

This study sought to identify the level of energy savings and management practices used in construction process in local contracting organisations. A systematic examination was conducted of local organisations using the 17 energy management requirements proposed in the study that reflected the application level of energy management in contractors' construction activities. It was found that the MS for the energy management requirements in the local construction sector were relatively low (i.e., had "poor application"), indicating that the organisations companies in the Gaza Strip did not strictly apply energy management practices in their projects. Some contracting organisations in the Gaza Strip have started to apply some energy management activities on a small scale in one way or another, but do not necessarily have well-structured frameworks. Conversely, other organisations, have not seriously considered energy management. Thus, it was found out that energy management has not been applied in a professional, systematic and planned manner in the local construction sector.

The study showed that contracting organisations in the Gaza Strip do not strictly apply energy management to their projects, as many of these organisations have not considered energy issues seriously. This issue requires special attention from stockholders in order to promote energy saving and conduct training and awareness programs for local contracting firms. The sampled organisations were not at ground zero in relation to their energy management practices: however, the overall performances of these organisations in energy efficiency and management were relatively low. This low application level was attributable to local contractors lacking any specified knowledge of energy management techniques and strategies. The main reasons for the energy management gap in the local construction sector were the existence of some barriers and an absence of motivation to save energy.

The results of this study results should be used to increase the social responsibility of contracting organisations towards energy use. The findings of this study will be valuable to construction practitioners in terms of saving energy and promote sustainable construction. Although this study is specific to Palestine, its results can be applicable to other developing countries. This study results should create more discussion on the subjects related to energy use and energy saving in construction. The results of this study should also be of immense use to policy makers, construction industry practitioners (e.g., clients, contractors and consultants) and academics. It is recommended to expand this study using qualitative method and involving other construction parties.

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REFERENCES

Abdelaziz, E.A., Saidur, R. and Mekhilef, S. (2011). A review on energy saving strategies in industrial sector. *Renewable and Sustainable Energy Reviews*, 15(1): 150–168. https://doi.org/10.1016/j.rser.2010.09.003.

Abd Elkhalek, H.A., Aziz, R.F. and Omar, A.F. (2015). Implementation of environmental management systems in construction industry. *International Journal of Education and Research*, 3: 407–432.

Abu Hamed, T., Flamm, H. and Azraq, M. (2012). Renewable energy in the Palestinian territories: Opportunities and challenges. *Renewable and Sustainable Energy Reviews*, 16(1): 1082–1088. https://doi.org/10.1016/j.rser.2011.10.011.

Adalberth, K. (1997). Energy use during the life cycle of buildings: A method. *Building and Environment*, 32(4): 317–320. https://doi.org/10.1016/S0360-1323(96)00068-6.

Akinbami, J.F. and Lawal, A. (2009). Opportunities and challenges to electrical energy conservation and CO_2 emissions reduction in Nigeria's building sector. Paper presented at the *Fifth Urban Research Symposium, Cities and Climate Change: Responding to an Urgent Agenda*. Marseille, France, 28–30 June. Available at: http://siteresources.worldbank.org/inturbandevelopment/resources/336387-1256566800920/6505269-1268260567624/akinbami.pdf [Accessed on 17 January 2014].

Al-Homoud, M. (2000). Total productive energy management. *Energy Engineering*, 97(5): 21–38.

Asian Productivity Organization (APO) (2008). *Working Manual on Energy Auditing in Industries*. Tokyo: APO. Available at: http://www.apo-tokyo.org/gp/e_publi/Working_Manual_on_Energy_Auditing.pdf [Accessed on 6 March 2014].

Ates, S.A. and Durakbasa, N.M. (2012). Evaluation of corporate energy management practices of energy intensive industries in Turkey. *Energy*, 45(1): 81–91. https://doi.org/10.1016/j.energy.2012.03.032.

Bartlet, J.E, Kotrlik, J.W. and Higgins, C.C. (2001). Organizational research: Determining appropriate sample size in survey research. *Information Technology, Learning, and Performance Journal*, 19(1): 43–50.

Bureau of Energy Efficiency (BEE) (2010). *Energy Management and Audit*. New Delhi: BEE. Available at: https://beeindia.gov.in/sites/default/files/1Ch3.pdf [Accessed on 6 February 2014].

Capehart, B.L., Turner, W.C. and Kennedy, W.J. (2003). *Guide to Energy Management*. 4th Ed. Georgia, USA: Fairmont Press Inc.

Chang, Y. and Ries, R. (2011). The energy and environmental implications of construction in China. Paper presented at the *Life Cycle Management Conference LCM 2011*. The Dahlem Cube, Berlin, 28–31 August.

Christoffersen, L.B., Larsen, A. and Togeby, M. (2006). Empirical analysis of energy management in Danish industry. *Journal of Cleaner Production*, 14(5): 516–526. https://doi.org/10.1016/j.jclepro.2005.03.017.

Chuanzhong, D. and Yingji, L. (2011). Constructing energy saving system based on low-carbon economy. *Energy Procedia*, 5: 1998–2002. https://doi.org/10.1016/j.egypro.2011.03.344.

Creative Research System (2014). *Sample Size Formulas*. California: Creative Research System. Available at: http://www.surveysystem.com/sample-size-formula.htm [Accessed on 11 September 2014].

Czaja, R. and Blair, J. (1996). *Designing Surveys: A Guide to Decisions and Procedures*. London: Pine Forge Press.

Davies, P.J., Emmitt, S. and Firth, S.K. (2013). On-site energy management challenges and opportunities: A contractor's perspective. *Building Research and Information*, 41(4): 450–468. https://doi.org/10.1080/09613218.2013.769745.

Davies, P.J., Emmitt, S., Firth, S.K. and Kerr, D. (2013). Addressing embodied energy from a contractor's perspective. In *SB13 Sustainable Building Conference Proceedings, 2013*. Coventry, UK: Coventry University.

de Groot, H.L.F., Verhoef, E.T. and Nijkamp, P. (2001). Energy saving by firms: Decision making, barriers and policies. *Energy Economics*, 23(6): 717–740. https://doi.org/10.1016/S0140-9883(01)00083-4.

de Vaus, D.A. (2002). *Surveys in Social Research*. 5th Ed. New South Wales: Allen and Unwin.

Dixit, M.K., Fernandez-Solis, J.L., Lavy, S. and Culp, C.H. (2012). Need for an embodied energy measurement protocol for buildings: A review paper. *Renewable and Sustainable Energy Reviews*, 16(6): 3730–3743. https://doi.org/10.1016/j.rser.2012.03.021.

Elaydi, H., Ibrik, I. and Khoudary, E.A. (2012). Scheme for energy saving measures in Gaza Strip at no cost. *Journal of Applied Sciences in Environmental Sanitation*, 7(4): 257–262.

Enshassi, A., Al-Hallaq, K. and Mohammed, S. (2006). Causes of contractor's business failures in developing countries: The case of Palestine. *Journal of Construction in Developing Countries*, 11(2): 1–14.

Enshassi, A., Al-Najjar, J. and Kumaraswamy, M. (2009). Delays and cost overruns in construction projects in the Gaza Strip, *Journal of Financial Management of Property and Construction*, 14(2): 126–151. https://doi.org/10.1108/13664380910977592.

Enshassi, A., Ayash, A. and Mohamed, S. (2018). Key barriers to the implementation of energy-management strategies in building construction projects. *International Journal of Building Pathology and Adaptation*, 36(1): 15–40. https://doi.org/10.1108/IJBPA-09-2017-0043.

Enshassi, A., Elzebdeh, S. and Mohamed, S. (2017). Drivers affecting household residents' water and related energy consumption in residential buildings. *International Journal of Building Pathology and Adaptation*, 35(2): 159–175. https://doi.org/10.1108/ijbpa-01-2017-0002.

Enshassi, A., Kochendoerfer, B. and Al-Ghoul, H. (2016). Factors affecting sustainable performance of construction projects' throughout project life cycle phases. *International Journal of Sustainable Construction Engineering and Technology*, 7(1): 50–68.

Enshassi, A., Kochendoerfer, B. and Rizqa, A. (2014). An evaluation of environmental impacts of construction projects. *Revista Ingenieria de Construction*, 29(3): 234–254.

Enshassi, A., Mohamed, S. and Abdel-Hadi, M. (2013). Factors affecting the accuracy of pre-tender cost estimates in the Gaza Strip. *Journal of Construction in Developing Countries*, 18(1): 73–94.

Enshassi, A., Mohamed, S. and Abushaban, S. (2009). Factors affecting the performance of construction projects in the Gaza Strip. *Journal of Civil Engineering and Management*, 15(3): 269–280. https://doi.org/10.3846/1392-3730.2009.15.269-280.

Enshassi, A., Mohamed, S. and Mayer, P. (2007). Factors affecting labour productivity in building projects in the Gaza Strip. *Journal of Civil Engineering and Management*, 13(4): 245–254. https://doi.org/10.3846/13923730.2007.9636444.

Global Superior Energy Performance Partnership - Energy Management Working Group (GSEP-EMWG) (2013). *Knowledge and Skills Needed to Implement Energy Management Systems in Industry and Commercial Buildings*. Paris: GSEP-EMWG, Clean Energy Ministerial. Available at: http://www.cleanenergyministerial.org/Portals/2/pdfs/GSEP_knowledge_skills_EnMS_implementation.pdf [Accessed on 14 April 2015].

Goldberg, A., Reinaud, J. and Taylor, R.P. (2011). *Promotion Systems and Incentives for Adoption of Energy Management Systems in Industry*. Washington: Institute for Industrial Productivity.

Gorkum, C.V. (2010). CO_2 emissions and energy consumption during the construction of concrete structures: Comparison between prefab and in-situ concrete viaducts. Research report. Delft University of Technology.

Israel, G.D. (2013). *Determining Sample Size (PEOD6)*. Gainesville, FL: Agricultural Education and Communication Department, Institute of Food and Agricultural Sciences, University of Florida.

Kahlenborn, W., Kabisch, S., Klein, J., Richter, I. and Schürmann, S. (2010). *DIN EN 16001: Energy Management Systems in Practice; A Guide for Companies and Organizations*. Berlin: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. Available at: https://globalcad.org/wp-content/uploads/2012/06/DIN-EN-16001-Energy-Management-Systems-in-Practice.pdf [Accessed on 4 March 2014].

Kannan, R. and Boie, W. (2003). Energy management practices in SME: Case study of a bakery in Germany. *Energy Conversion and Management*, 44(6): 945–959. https://doi.org/10.1016/S0196-8904(02)00079-1.

Kostka, G., Moslener, U. and Andreas, J. (2013). Barriers to increasing energy efficiency: Evidence from small and medium-sized enterprises in China. *Journal of Cleaner Production*, 57: 59–68. https://doi.org/10.1016/j.jclepro.2013.06.025.

Majdalani, Z., Ajam, M. and Mezher, T. (2006). Sustainability in the construction industry: A Lebanese case study. *Construction Innovation*, 6(1): 33–46.https://doi.org/10.1108/14714170610710613.

Ministry of Planning and Administrative Development (MoPAD) (2012). *Sustainable Development under Israeli Occupation: Achievements and Challenges*. Ramallah: MoPAD.

Muhaisen, A. and Ahlbäck, J. (2012). *Towards Sustainable Construction and Green Jobs in the Gaza Strip*. Geneva: International Labour Organization. Available at: http://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/publication/wcms_184265.pdf [Accessed on 3 February 2014].

Naing, L., Winn, T. and Rusli, B.N. (2006). Practical issues in calculating the sample size for prevalence studies. *Archives of Orofacial Sciences*, 1: 9–14.

Naoum, S. (2007). *Dissertation Research and Writing for Construction Students*. 2nd Ed. Oxford: Elsevier Ltd.

Ndayiragije, A. (2006). Modelling study of energy use on a construction site. MScEng diss. Strathclyde University.

Pallant, J. (2005). *SPSS Survival Manual: A Step by Step Guide to Data Analysis Using SPSS for Windows (Version 12)*. 2nd Ed. New South Wales: Allen and Unwin.

Palestinian Central Bureau of Statistical (PCBS) (2016). *Palestine in Figures 2013*. Ramallah: PCBS. Available at: http://www.pcbs.gov.ps/portals/_pcbs/downloads/book2040.pdf [Accessed on 24 January 2016].

Palestinian Contracting Union (PCU) (2016). *Palestinian Contracting Union: Internal Report*. Gaza: PCU.

Rohdin, P., Thollander, P. and Solding, P. (2007). Barriers to and drivers for energy efficiency in the Swedish foundry industry. *Energy Policy*, 35(1): 672–677. https://doi.org/10.1016/j.enpol.2006.01.010.

Russell, C. (2005). Energy management path finding: understanding manufacturers' ability and desire to implement energy efficiency. *Strategic Planning for Energy and the Environment*, 25(3): 20–54. https://doi.org/10.1080/10485230509509690.

Saunders, M., Lewis, P. and Thornhill, A. (2009). *Research Methods for Business Students*. 5th Ed. Harlow, UK: Pearson Education.

Saravanan, V.K. (2011). Cost effective and sustainable practices for piling construction in the UAE. MSc diss. Heriot-Watt University.

Sustainable Buildings and Climate Initiative, United Nations Environment Programme (UNEP-SBCI) (2009). *Buildings and Climate Change: Summary for Decision-Makers.* Paris: UNEP-SBCI. Available at: http://www.unep.org/sbci/pdfs/sbci-bccsummary.pdf [Accessed on 10 March 2014].

Tan, Y., Shen, L. and Yao, H. (2011). Sustainable construction practice and contractors' competitiveness: A preliminary study. *Habitat International*, 35(2): 225–230.https://doi.org/10.1016/j.habitatint.2010.09.008.

The Carbon Trust (2011). *An Introduction to Energy Management*. London: The Carbon Trust. Available at: http://www.carbontrust.com/media/7385/ctv045_an_introduction_to_energy_management.pdf [Accessed on 6 January 2014].

Thollander, P., Backlund, S., Trianni, A. and Cagno, E. (2013). Beyond barriers: A case study on driving forces for improved energy efficiency in the foundry industries in Finland, France, Germany, Italy, Poland, Spain and Sweden. *Applied Energy*, 111: 636–643.https://doi.org/10.1016/j.apenergy.2013.05.036.

Treloa, G.J. (1998). A comprehensive embodied energy analysis framework. PhD diss. Deakin University.

Turner, W. and Doty, S. (2009). *Energy Management Handbook*. 6th Ed. Georgia, USA: Fairmont Press Inc.

United Nations Centre for Human Settlements (UNCHS) (1991). *Energy for Building: Improving Energy Efficiency in Construction and in the Production of Building Materials in Developing Countries, Report No. HS/250/91*. Nairobi: UNCHS "Habitat". Available at: http://unhabitat.org/books/energy-for-building-improving-energy-efficiency-in-construction-and-in-the-production-of-building-materials-in-developing-countries [Accessed on 22 July 2014].

United Nations Industrial Development Organization (UNIDO) (2007). *Policies for Promoting Industrial Energy Efficiency in Developing Countries and Transition Economies*. Vienna: UNIDO. Available at: http://www.unido.org/fileadmin/media/documents/pdf/Energy_Environment/ind_energy_efficiencyEbookv2.pdf [Accessed on 30 December 2013].

United Nations Office for the Coordination of Humanitarian Affairs (OCHA) (2008). *Gaza Humanitarian Situation Report Power Shortages in the Gaza Strip*. East Jerusalem: OCHA. Available at: http://www.ochaopt.org/documents/Gaza_Situation_Report_2008_01_08.pdf [Accessed on 7 January 2014].

World Bank (2007). *West Bank and Gaza Energy Sector Review, Report No. 39695-GZ*. Washington DC: Sustainable Development Department (MNSSD), Middle East and North Africa Region, World Bank. Available from: http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2007/08/01/000020953_20070801113123/Rendered/PDF/396950GZ0Energ1white0cover01PUBLIC1.pdf [Accessed on 25 February 2014].

Yan, H., Shen, Q., Fan, L.C.H., Wang, Y. and Zhang, L. (2010). Greenhouse gas emissions in building construction: A case study of One Peking in Hong Kong. *Building and Environment*, 45(4): 949–955. https://doi.org/10.1016/j.buildenv.2009.09.014.

Yaseen, B.T.Q. (2008). Energy efficiency improvement and cost saving measures in some different industries in Palestine. MScEng diss. An-Najah National University.