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Faculty of Graduate Studies

Assessing the Life Cycle Cost Saving Associated with Reduced Energy Consumption in Green Schools in Palestine: A Case Study

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Dedication

I would like to dedicate this work to my beloved parents who have been supporting me throughout this journey and who gave me strength when I thought of giving up.

To my precious husband; Tareq Dumaidi who has encouraged me all the way and who gave me an endless support to make sure that I completed what I started.

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To my sisters and brothers, who hold in their eyes the memories of my childhood and my youth.

To my friends and relatives who have meant and continue to mean so much to me.

I dedicate this work and give a special thanks to my supervisors; Dr. Luay Dwaikat and Dr. Muhannad Haj Hussein who shared their words of advice and helped me to finish this work.

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I am grateful to my sisters and brothers, whose love and guidance are with me in whatever I pursue. Most importantly, I would like to thank my loving and supportive husband, and my two wonderful daughters, who provide unending inspiration.

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الاقرار

أنا الموقعة أدناه، مقدّمة الرسالة التي تحمل العنوان:

Assessing the Life Cycle Cost Saving Associated with Reduced Energy Consumption in Green Schools in Palestine: A Case Study

أقر بأن ما اشتملت عليه هذه الأطروحة إنما هو نتاج جهدي الخاص، باستثناء ما تمت الاشارة إليه حيثما ورد. وأن هذه الرسالة كاملة، أو اي جزء منها لم يقدم من قبل لنيل اي درجة او لقب علمي او بحثي لدى أي مؤسسة تعليمية أو بحثية أخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's Name: **إسم الطالبة:** سوسن جمال [illegible]

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Date: **التاريخ:** 6/9/2020

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List of Abbreviations

CO2	Carbon Dioxide.
ISO	The International Organization for Standardization.
LCA	Life Cycle Assessment.
LCC	Life Cycle Cost.
PV	Photovoltaic.
ASTM	American Society of Testing and Materials.
PCBS	Palestinian Central Bureau of Statistics.
CPI	Consumer Price Index.
EEI	Energy Efficiency Index.
LEED	The Leadership in Energy and Environmental Design.
BREEAM	Building Research Establishment Environmental Assessment Method.
PBRS	Pearl Building Rating System.
PHGBC	Palestine Higher Green Building Council.
SD	Sustainable Development.
WLC	Whole Life Cost.
NPV	Net Present Value.
IQR	Interquartile Range.
kWh	Kilo Watt Hour.
ILS	Israeli Shekel.
kWp	Kilo Watt Peak of a system.
BEI	Building Energy Index.
EEI	Energy Efficiency Index.

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Abstract

Several literature sources suggest that green buildings outperform non-green buildings particularly in term of economic benefits. Notwithstanding, the green building movement is still nascent in Palestine and few buildings are officially registered and rated as green by the official certification bodies. On a larger scale, it is also argued in the body of literature that building owners and real estate developers are still hesitant to adopt the concept of green buildings. Among others, the economic factors are placed in the forefront of the factors that affect owners' decisions to go green. In this research, and due to the need to enhance the empirical evidence for the economic benefits associated with reduced energy consumption in green schools locally and globally, an energy life cycle cost analysis is conducted for the first officially registered green school in West Bank/Palestine. Methodologically, in this research an energy life cycle cost baseline for public (non-green) schools in Palestine is established. The energy consumption baseline is essential to measure the actual economic performance of the green school in term of energy consumption. Then, life cycle costing is used as an economic evaluation technique. Part of the life cycle cost analysis, this research also examines how different scenarios for energy price inflation would affect the cost saving associated with reduced energy consumption in the green school compared to public schools in West Bank/Palestine throughout its whole life cycle, which extends for 60 years.

It is found in the research that the baseline energy consumption in public schools in West Bank/Palestine is 10,367.63 kWh/year, this corresponds to a building energy index (BEI) of 8.34 kWh/m^2/year. From life cycle perspective, this yield a baseline life cycle energy cost of 766,370.59 ILS at 2% average annual increase in energy price. While the actual energy consumption in the green school is 8,895.50 kWh/year, this corresponds to a building energy index (BEI) of 6.32 kWh/m^2/year, which yields a life cycle cost for energy equals 722,262.93 ILS considering 2% average annual increase in energy price. It is also found that the green school saves 24.22% in terms of energy consumption compared to non-green schools.

From life cycle perspective, it is also found that the savings from the green school PV-system is 284,187.70 ILS at 2% inflation rate which corresponds to 86.56% from the life cycle energy saving.

Chapter One
Introduction

This chapter provides a general overview that outlines the thesis topic and gives a background information that enables the reader to follow this research context. A brief background, research problem, research scope, research objectives, research questions, research significance and structure are also presented in this chapter.

1.1 Background

As a result of the modern lifestyle, the world faces several environmental problems that affect the environment and the global climate such as: global warming, CO_2 emissions, and ozone layer depletion (Patz et al., 2003). Climate change and its negative impact on the environment has led the world towards what is termed as "Sustainable Development" (Sinha et al., 2013).

In 1987, Brundtland Commission defined sustainable development in its report entitled "Our Common Future" as "*meeting the needs of the present without compromising the ability of future generations to meet their own needs*" (Brundtland, 1987, p. 16). The term "sustainable development" is linked within the context of environmental concerns since its emerged (Hák et al., 2016). According to Sinha et al.(2013), increasing economic efficiency, improving human well-being and preserving natural resources are considered some of the sustainable development goals.

In order to achieve sustainable development goals, several manufacturing and industrial sectors were hesitant in adopting sustainable practices. Within this context, research shows that among the other industrial sectors, the construction sector consumes a major share of energy worldwide (Masoso & Grobler, 2010). According to Pe´rez-Lombard et al. (2008), the global contribution of energy consumption for both residential and commercial buildings has increased to reach figures between 20% and 40% of the total final energy consumption in developed countries. Hence, due to the negative environmental impact of the construction sector, a relatively recent concept which is sustainable construction has emerged (Ding, 2008).

According to Kibert (2016), sustainable construction can be defined as a way of utilizing resource efficiency and ecological design in creating a healthy built environment. Sustainable construction deals with the social, ecological and economic issues of the buildings by: using resources efficiently, minimizing waste (Salama & Hana, 2010), protecting the nature, eliminating toxics and the reuse of resources (Matar et al., 2008). The increased demand for resource-efficient buildings that use energy and water in minimal rates and the climate change threat on the environment has lead professionals towards the concept of green buildings (Kibert, 2016).Green or sustainable building was defined by (Sinha et al., 2013, p. 46) as: "*practice of creating structures and using processes that are environmentally responsible and resource efficient throughout a building life-cycle from siting to design, construction, operation, maintenance,* *renovation, and deconstruction*". According to Li et al. (2017), reducing consumption of materials, water, and improving indoor environmental health in green buildings can result in the reduction of buildings adverse impacts on the environment.

Abdelfattah (2017) suggested that using the land and energy efficiently, increasing the use of recycled materials and conserving water and other resources are all considered as indicators for creating green buildings.

Green buildings design aims to protect occupant health and improve their productivity, in addition to optimize the use of resources and to increase building efficiency in energy, water and materials usage throughout the building life cycle (Electric, 2006; Kibert, 2012).

The large motivation of green buildings practices in evaluating the effects of structural design on human health and productivity, pay attention to the essential need of developing school buildings design that combine between healthy environment for learning and ways of saving energy (Lysgaard et al., 2015; MAGZAMEN et al., 2017). Green schools appeared to respond to this need, since green schools design can improve the indoor environmental quality of the school by preventing the outdoor exposures (Breysse et al., 2011; Howden-chapman et al., 2009). According to Dwaikat & Ali (2018b) , energy efficiency is considered as a key driver for the green building movement.

Within the same context, Hussain (2016) suggests that there are five potential sustainable structure design methodologies illustrated in minimizing material use, embodied energy, material production energy, maximizing structural reuse and the implementation of life cycle analysis and life cycle assessment.

According to the International Organization for Standardization ISO 15686-5 (2006), life cycle assessment (LCA), is used to assess and quantify environmental impacts. Davis Langdon (2007a, p. 2) defined life cycle assessment as a method that measures the energy used within a building throughout its life cycle for the purpose of evaluating its environmental performance. Also, when there is a need for comparing different design alternatives of a new building LCA can be used (Davis Langdon, 2007a).

In order to have an efficient way for assessing both environmental and financial loads in one assessment, a combination of life cycle assessment and life cycle cost should be used (Buyle et al., 2012).

Life cycle cost (LCC), relates to the cost of building and maintaining the structure over its service life (ISO14044, 2006). Accordingly, LCC includes all types of financial costs of a product or process that is needed for assessing total cost over time (Kubba, 2010).

Typically, LCC analysis may be used during four different stages of the life cycle of any constructed asset (ISO15686-5, 2008). These four stages are planning phase, construction phase, operating and maintenance phase, and the end of life phase (ISO15686-5, 2008).

It must be mentioned that, almost 80% of energy is being consumed during the building’s life cycle operation phase (Liang et al., 2016). Studies on the total energy use during buildings life cycle are needed to measure their energy performance and to develop solutions for reducing energy consumption in buildings (Ramesh et al., 2010).

Therefore it is very important to assess and analyze the energy consumption in buildings for the purpose of reducing energy demand, as well as to find effective solutions for improving energy efficiency (Ma & Cheng, 2016; Najihah et al., 2015).

In order to assess and measure the energy consumption in buildings, an energy baseline should be established to be used as a benchmark to measure and compare energy usage and to quantify the energy savings that result from energy efficient buildings. It must be mentioned that due to the variation of energy used patterns throughout the world, the availability of a universal energy baseline is yet to be found.

In light of the previous discussion, this research is undertaken in order to establish an energy consumption baseline for public schools in West Bank/ Palestine. Furthermore, the aim of the work presented in this research is to present an estimation of the life cycle cost of energy in public schools in West Bank/ Palestine, and to quantify the life cycle cost saving associated with reduced energy consumption in the first green school in Palestine which is Aqqaba green school. Since there is a trend in the Palestinian Ministry of Education to reduce the energy consumption in schools by installing PV-systems in each school.

1.2 Research Problem

In 2016, the Palestinian Green Building Council commissioned the first certified green school in Palestine, which is Aqqaba green school. This has been perceived as a practical step in adopting the concept of sustainable construction and green buildings by the Ministry of Education in Palestine.

In a master degree research, Hodiri (2018) conducted a research to evaluate the actual performance of Aqqaba green school and reported that the actual performance of the green school is much lower than the expected performance in the design phase, and he found that Aqqaba green school consumed less energy than non-green schools buildings by 4.84%.

Hodiri (2018), also reported that the green school generates an income of 2,297 ILS/year from on-grid energy production through a photovoltaic (PV) system installed in the green school. However, these results call for the need to evaluate these benefits for life cycle perspective. Therefore, empirical evidence is required in order to find out if the green solutions adopted in Aqqaba green school are economically feasible from the life cycle perspective. So far, there has not been any empirical evidence that quantify the energy savings for school buildings in Palestine from the life cycle cost perspective.

As a result, estimating the life cycle cost of energy consumption in schools will help in determining the size of savings associated with reduced energy consumption in green schools compared to conventional (non-green) ones in West Bank/ Palestine.

1.3 Research Questions

This research was conducted to answer the following questions:

1. How much is the average energy consumption of public schools in Palestine?

2. How much is the life cycle cost of energy consumption in public schools in Palestine?

3. How much is the life cycle cost saving associated with reduced energy consumption in Aqqaba green school compared to conventional (non-green) schools in Palestine?

1.4 Research Objectives

The main objective of this research is to conduct an estimation of the life cycle cost of energy in public schools in Palestine and to quantify the life cycle cost saving associated with reduced energy consumption in the first green school in Palestine which is Aqqaba green school. In addition, this research was also undertaken to achieve the following objectives:

1. Establish energy consumption baseline for public schools in Palestine.

2. Estimate the life cycle cost of energy consumption in public schools in Palestine.

3. Quantify the life cycle cost saving associated with reduced energy consumption in Aqqaba green school compared to conventional (non-green) schools in Palestine.

1.5 Research Scope

This research will be conducted in Palestine, specifically for the public sector schools located only in West Bank. Gaza strip will be excluded in this research, because of the limited time for preparing this research and the political obstacles that faces entering Gaza.

1.6 Research Significance

This research provides an estimation of the size of savings associated with reduced energy consumption in green schools compared to conventional ones in Palestine from the life cycle perspective. Also, this research measures the economic benefits gained from the green features incorporated in Aqqaba green school. In addition, this research established energy consumption baseline and energy life cycle cost baseline for public school buildings in Palestine. The energy consumption baseline is imperative for future research to assess the actual energy performance of schools in Palestine.

1.7 Research Structure

This thesis adopts the following structure:

Chapter one “Introduction” introduces a general background about the thesis subject, in addition to the research problem statement, research objectives, research questions, research scope and the significance of the study.

Chapter two synthesizes the body of relevant literature by presenting reviews for articles, books, reports and previous studies that are related to sustainable development, sustainable construction, green buildings and their benefits, costs and barriers. In addition to dissection of life cycle assessment LCA and life cycle cost LCC methods.

Chapter three summarizes the adopted research methodology, explores research population and sampling, data collection techniques, data analysis approach and a brief description of the research case study.

Chapter four “Data Collection” provides how the required data was collected, and why the research sample was selected. Also, the chapter explores all the collected data and their sources.

Chapter five “Data Analysis and Discussion” presents the detailed steps of how the collected data was analysed, and how the energy life cycle cost baseline was established throughout a detailed discussion of the research findings.

Chapter six “Conclusions and Recommendations” summarizes the research conclusions, limitations, recommendations and suggestions of possible future work.

Chapter Two
Literature Review

This chapter provides a summary of the literature that addresses the topic of sustainable development and sustainable construction. This chapter also presents green buildings concepts, costs and advantages, in addition to a brief description of green buildings in Palestine. Besides, Life Cycle Assessment (LCA) and Life Cycle Cost (LCC) concepts, elements and equations that comprise the main objective of this research are discussed and highlighted in details in this chapter.

2.1 Sustainable Development

Due to the environmental movement of the early 1970s, the concept of “sustainability” began growing (Akbarnezhad, 2014). In general, sustainability means continued development or growth by achieving balance between economics, equity and environmental impacts without deterioration and depletion of natural resources (Kibert, 2012). The starting point of the concept of sustainability appeared in 1972 in the United Nations Conference on the Human Environment without the use of the term sustainable development (Handl, 2012).This conference stresses *“the need for restraint on natural resource use, consistent with the carrying capacity of the earth, for the benefit of present and future generation”* (Handl, 2012, p. 4). However, in 1987 the term “sustainable development” was suggested by the United Nations World Commission on Environment and Development (Brundtland, 1987). Also an effort was exerted for linking the issues of economic development and environmental stability in the Brundtland Commission (Abdelfattah, 2017). Therefore, Bruntland Commission ended up with published report (Our Common Future) that defined the concept of sustainable development as “the development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland, 1987, p. 16). The definition of sustainable development suggests that human, economic and natural systems are interdependent. Also it emphasizes the importance of environment and the quality of human life (Kibert, 2012). In addition, sustainable development is considered as a pattern of growth, in which resources can be used to meet human needs with the importance of preserving the environment to ensure that these needs can be met in the present and for upcoming generations (Abdelfattah, 2017). Therefore, sustainable development is about finding better ways of doing things for the future and the present (Kates et al., 2005), besides achieving a good balance between the environment, the society and the economy (Giddings et al., 2002).

The importance of sustainable development stems from its objectives. Abdel Fattah (2017) mentioned five main objectives of sustainable development which can be summarized as improving quality of life, promoting equity, sustaining natural resources, protecting humans health, and finally meeting international obligations.

As a result of those objectives and in order to increase the economic efficiency, improve human well-being and to rapidly move towards zero energy construction, sustainability has become a key consideration of building practitioners (Sinha et al., 2013). Besides, the environmental impact of construction and environmental building performance assessment have led professionals towards sustainable construction design (Ding, 2008).

2.2 Green Buildings

2.2.1 Sustainable Construction

The huge consumption of global resources and the environmental pollution that caused by construction industry, led the world towards sustainable construction design that ensures the achievement of sustainable development goals and minimize construction impacts on the environment (Ding, 2008).

Sustainable construction was defined in Agenda 21 for Sustainable Construction in Developing Countries as "*a holistic process aiming to restore and maintain harmony between the natural and built environments, and create settlements that affirm human dignity and encourage economic equity*" (Du Plessis, 2002, p. 8). Moreover, in 1994, the Conseil International du Batiment defined the goal of sustainable construction as "*creating and operating a healthy built environment based on resource efficiency and ecological design*" (Kibert, 2016, p. 1).

Sustainable construction aims to achieve the goals of economic sustainability by: making more efficient use of resources in order to increase profitability, social sustainability: by providing customers satisfaction in order to achieve their needs at all stages of the construction process, and finally environmental sustainability by minimizing waste and preserving natural resources in order to protect the environment (Salama & Hana, 2010).

Intrinsically, sustainable construction has principles that should be applied across the entire life cycle of the construction (Kibert, 2012). These principles can be summarized as: reducing resource consumption, using recyclable resources, protecting the nature, eliminating toxics, reuse resources, focus on quality, and applying life cycle costing (Matar et al., 2008). Technically, these principles should be applied to the built environmental resources: energy, water, land, materials and ecosystems, during the entire life cycle (Kibert, 2012).

The use of sustainable construction principles in creating actual structure quality and characteristics refers to what is called high-performance buildings or green buildings (Kibert, 2016).

2.2.2 Green Buildings

Although, sustainable development and green buildings are related, they are not the same (Sinha et al., 2013).Green designs involve using the imagination and technical knowledge to design and build in compliance with the environment requirements. The challenge is to find the balance between the environmental considerations and the economic constraints (Haddad, 2010). Besides, buildings should maintain a group of environmental aspects during the stages of their construction, operation, disposal and recycling, in order to be considered as sustainable building (Dwaikat & Ali, 2016).

According to Filippi and Sirombo (2015, p. 1), a green building is defined as *"a healthy facility designed and built in a cradle-to-grave resource-efficient manner, using ecological principles, social equity, and lifecycle quality value"*. Another definition of green building is *"a current design attitude which requires the consideration of resources reduction and waste emissions for the period of its whole life cycle"* (Wang et al., 2005, p. 1). Furthermore, Connor et al.(2015, p. 7) defined green buildings according to the American Society of Testing and Materials (ASTM) Standard E2114-06a as *"a building that provides the specified building performance requirements while minimizing disturbance to and improving the functioning of local, regional and global ecosystems during and after its construction and specified service life."*

According to Kibert (2012), green buildings aim to decrease the building adverse impact on environment and human health. Besides, it aims to increase the building efficiency in using energy, water and materials throughout the building life cycle.

As an application of the green building concept, green schools have emerged. This is because it combines healthy environment for learning and ways of saving energy (Lysgaard et al., 2015). According to Dwaikat and Ali (2018b), energy efficiency is considered a key driver for the green building movement. Green buildings are expected to be a highly energy and water preservation structures. According to Kibert (2012), green buildings are based on employing renewable energy resources, implementing passive design, and designing buildings that are resistant to conductive, convective, and radioactive heat transfer. Also, green buildings design contains different approaches for waste water treatment and storm water management that leads to water preservation through the use of low-flow plumbing fixtures, water recycling and rainwater harvesting.

In order to measure the environmental performance of buildings, green rating systems worldwide were established. According to IFMA (2015), several rating systems that offer certifications are currently available throughout the world, some of the most widely used systems are: The Leadership in Energy and Environmental Design (LEED) rating system. It was developed by the U.S. Green Building Council. Initially, LEED rating system was established for new construction, recently however, most of the LEED rating systems focus on the design and construction stages of a building (IFMA, 2015).

Another rating system is the Green Globes. It was offered in Canada, the United States and the United Kingdom. It has two rating systems, one for existing buildings and the other for new buildings (IFMA, 2015). In 1990, the British Building Research Establishment Environmental Assessment Method (BREEAM) was launched in UK. This system's evaluation is expressed as a percentage of success over total available points: 85% for Outstanding, 70% for Excellent, 55% for Very Good, 45% for Good and 30% for pass classification. It is worth mentioning that there is an international version of BREEAM for certifying projects worldwide (BRE Global, 2016).

The Green Star rating system is used in Australia, New Zealand and South African. Green Star ratings are available for every building type, with the exception of free standing homes (IFMA, 2015).

Furthermore, using the elements of LEED and BREEAM, a new rating system, referred to as Estidama, was developed (Elgendy, 2010). Estidama Pearl Rating System was established in 2010 by Abu Dhabi Urban Planning Council. There are five levels of certifications which can be obtained using the Pearl Building Rating System (PBRS) : one Pearl (All mandatory credits), two Pearls (All mandatory credits + 60 points), three Pearls (All mandatory credits + 85 points), four Pearls (All mandatory credits + 115 points), and five Pearls (All mandatory credits + 140 points) (Abu Dhabi Urban Planing Council, 2010).

Locally, the Palestinian green buildings guidelines were established in 2013 by the Palestinian Engineers Association with the help of Palestine Higher Green Building Council (PHGBC). The Palestinian green buildings guidelines were established to reduce the environmental problems that faces Palestine in particular. According to Palestine Engineers Association (2013), Palestine environmental problems includes limited resources of energy and water and the high operating cost of buildings in Palestine.

The Palestinian green building guidelines have classified the Green buildings into four main categories according to the total points earned by the building: the Diamond category which include a rating of 160 points or more, the Golden category with 140-159 points, the Silver category with 120-139 points and the Bronze category with 100-119 points.

2.2.3 Green Buildings Barriers

There are several barriers that prevent widespread applications of the concept of green buildings around the world (Chan et al., 2016). In the Malaysian construction industry, Samari (2013) surveyed 167 professionals for discovering barriers to green building in Malaysia. They found that the lack of credit resources to cover the upfront cost, lack of demand, higher final price of green buildings units and risk of investment are the main barriers of green buildings. Also in almost 60 Nigerian companies Ikediashi (2012) found that the main barrier to sustainable green building is top management reluctance for promoting sustainable construction, in addition to lack of awareness and sufficient training and tools.

According to Chan et al. (2016), barriers that prevent green building are divided into five main categories as follows:

1. Economic issues that result from the lack of incentives, higher investment cost, risk of investment and time delays since any project delay in employing green practices will result in a serious economic implications (Chan et al., 2016; Samari et al., 2013).

2. Technology and training issues: most of the green technologies are complex and require technical considerations in order to meet the desired sustainability goals (Ikediashi et al., 2012).

3. Information, Knowledge, and Awareness Issues: without sufficient research and information it is difficult to create public awareness for green buildings (Chan et al., 2016).

4. Management and Governmental issues: top management support for the adoption of green buildings and the governments involvement and support in formulating green buildings codes, regulations and evaluation standards are very important (Ikediashi et al., 2012).

5. Attitude and Market: lifestyle, behavior of stakeholders, and culture cannot be properly controlled in the green buildings market (Chan et al., 2016).

2.2.4 Green buildings Benefits and Costs

Construction sector is considered to be one of most the costly investments, because of buildings operation and maintenance costs. In a study conducted by Dwaikat & Ali (2018a) for a green office building in Kuala Lumpur, it was found that operating cost forms 48% of a total life cycle budget, while building maintenance cost forms about 27%, which is higher than the design and construction cost.

According to Kats et al. (2003), a financial benefit that is 10 times higher than the cost of constructing buildings which meet green design criteria can be achieved by lower maintenance cost, reduced energy and water consumption and improved health and productivity.

Also, In a study conducted by Morrissey and Horne (2011) in Australia about the energy efficiency in residential buildings using the energy life cycle cost analysis, it was shown that when designing a building that is more thermally efficient, the energy cost savings associated with the building design exceeds the higher construction cost.

Benefits of green buildings drive the world to build and operate facilities in a green manner (Electric, 2006). Green buildings are considered to be more efficient in using resources like energy, water, materials, and land (Electric, 2006). Because green buildings provide cost savings since they save energy, use less water, have a lower operating and maintenance costs, generate less waste and provide solutions to pressing health, environment and economic challenges (Electric, 2006). Also, green buildings improve employees and students health, comfort, and productivity by using natural day lighting and better air quality (Electric, 2006).

According to a detailed review conducted on 121 LEED rated buildings by Hewitt (2008), green buildings are considered to be more energy efficient than conventional buildings by 25-30%.

Likewise, in a study for a precast concrete manufacturing facility (a green manufacturing facility) located in Pennsylvania, Ries et al.(2006) found 30% decrease in energy consumption and 25% increase in productivity. In addition, Yudelson (2008) reports that green buildings use (30-50) % lower energy and water than non-green buildings. Moreover, the Green Building Councel in Australia (2006) found a reduction of building annual operating costs due to 60% decrease in energy and water consumption based on several Australian and international case studies and research. Also, the Green Building Councel in Australia (2006) found 1-25% productivity increase.

According to Fowler and Rauch (2008), the US General Services Administration conducted an evaluation of 12 of its green designed buildings against the average performance of US commercial buildings in 2007. The evaluation focused on evaluating financial metrics, occupant satisfaction, and environmental performance. The results confirmed that the green designed buildings emit 33% CO_2 less than the national average, have 13% lower maintenance cost, 26% less energy usage and 27% higher levels of occupants satisfaction (Kim M. Fowler & Rauch, 2008).

According to Fowler et al. (2010), a second US General Services administration study of was carried out on another 10 representative green buildings from its national portfolio, in addition to the 12 sustainable green buildings that were evaluated in 2007 as mentioned above. The selected buildings were evaluated for waste generation and recycling, occupant satisfaction, operations and maintenance, carbon emissions and energy use. The results confirmed that buildings in new study emit 36% CO_2 less than the national average, have 25% less energy usage, 19% lower aggregate operational costs, and 27% higher levels of occupants' satisfaction than national average. These results were consistent with those obtained from the first one (Fowler et al., 2010).

According to Kats et al.(2003), an increment in the cost of building green by 2% would achieve life cycle saving by 20% of the total construction cost which equals more than ten times the initial investment.

A study was conducted in 2005 by the US department of Energy Information Administration in order to collect data about how much US households spend on energy. A sample of 4381 households in the United States were surveyed. The result showed that they spent about $201 billion on energy in 2005, which equals $8.93 per m^2 (U.S. Green Building Council, 2011).

In 2007, a study for the purpose of estimating the cost of green buildings compared to conventional buildings was conducted. According to Kats (2013), the study was performed on 170 US green buildings. Data about water and energy usage, health and productivity were collected and analyzed, the study ended up with a cost of green buildings 2% more than conventional buildings.

Studies by Morris & Matthiessen (2007) were performed in 2005 and 2007 on 221 green and non-green buildings found that there is no statistical differences between the cost of green and non-green buildings.

Dwaikat and Ali (Dwaikat & Ali, 2018b) analyzed the actual energy performance of a green building in use. An energy saving of 71.1% compared to the industry baseline was found in the investigated green building. Also Dwaikat and Ali (2018b) found that from life cycle perspective an increment of 1% in average annual energy price can cause 5,756 kWh/m^2 savings which equals $2,796,451 in the investigated green building.

The sited of literature suggests that the green building has numerous benefits, particularly, in term of the economic performance. Green buildings design has the potential to lower maintenance and operational costs, optimize the use of resources and increase building efficiency in energy, water and materials usage throughout the building life cycle, as well as maximization of utility and investment returns in the building sector.

2.2.5 Green Buildings in Palestine

About 80% of Palestinian territories energy sources come from neighboring countries to meet their energy demands (Ismail et al., 2013). Almost all energy consumed in Palestine is imported with heavy taxes, therefore energy price is considered to be relatively high (Abu-hafeetha, 2009).

According to Yaseen (2007), a notable growth in energy demand levels in Palestine is expected to happen due to the development plan in Palestine that aims to improve the quality of life for the Palestinians.

Table 2.1 below represents the amount of energy consumption in Palestine between 2001-2017 as published by the Palestinian Central Bureau of Statistics (2018).

Table 2.1: The consumed amount of energy in Palestine between year 2001-2017.

Year	2001	2002	2003	2004	2005	2006
The consumed amount of energy (megawatt-hour)	2,049,979	2,137,910	2,217,818	2,591,243	2,390,119	2,360,438
Year	2007	2008	2009	2010	2011	2012
The consumed amount of energy (megawatt-hour)	2,956,376	3,054,139	3,515,840	3,280,240	3,505,890	4,845,514
Year	2013	2014	2015	2016	2017	-
The consumed amount of energy (megawatt-hour)	4,743,316	4,641,898	5,216,380	5,289,136	5,387,990	-

Table 2.1 supports the fact that the energy demand in Palestine has been growing, as the consumption has increased by 61.10% from year 2001 to 2017.

In Palestine, the residential sector has an energy consumption percentage of 50%, while the industrial sector has a percentage of 15%, the pumping stations have a percentage of 15% and the commercial and governmental sectors have a percentage of 10% (Ibrik & Mahmoud, 2002; Mahmoud & Ibrik, 2002).

Palestine is witnessing increased energy demand due to the improvement of living conditions and increased population growth which cause increasing demand for building services and comfort levels (Pe´rez et al., 2008; Yaseen, 2007). According to Ismail et al.(2013), a reduction in energy consumption can be achieved by the improvement of energy efficiency in different sectors in Palestine.

Countries like Palestine are still taking the initial steps towards achieving sustainable development, while developed countries have been developing and implementing standards and regulations for sustainability (Rustom, 2014).

Recently, the concerns about implementing the concept of green buildings in Palestine are increasing according to Palestine Engineers Association (2013). And different institutions that are concerned with sustainable issues have been established such as “Palestine Higher Green Building Council”.

The purpose of implementing the concept of green buildings in Palestine is to fill the gap between sustainable and typical designs in Palestine, and to enhance the use of the available resources in an efficient way during building construction and operation stages (Palestine Engineers Association, 2013). Also, the need for sustainable green building in Palestine is highlighted even more due to the limited control over energy and water resources due to the political complications (Palestine Engineers Association, 2013).

According to Palestine Engineers Association (2013), the Palestine Higher Green Building Council issued the "Green buildings Guidlines - State of Palestine" in order to be followed in the different stages of constructing green buildings in Palestine.

The Palestinian Green Buildings Guidelines divides green buildings in Palestine into four main categories according to their rating based on the outcome of the required assessment process (Palestine Engineers Association, 2013). The four categories of green buildings in Palestine are: Bronze category buildings, Silver category buildings, Golden category buildings, and Diamond category buildings (Palestine Engineers Association, 2013).

As an application of the green building concept in Palestine, green schools have emerged. In general, Palestinian public schools mainly use energy for purposes of lighting, electrical heaters and small fans as HVAC systems are not available in Palestinian public schools (Haj Hussein et al., 2016).

According to Haj Hussein et al. (2016) and due to the lack of heating systems in public schools, students and teachers attempt to compensate for needed heating inside classrooms by closing doors and windows. This method has a negative impact on students' performance and the air quality inside classrooms (Haj Hussein et al., 2016). Therefore, new systems and procedures should be proposed to improve environmental comfort and energy-efficiency (Haj Hussein et al., 2016). This can be achieved by implementing the green schools' concept.

An obvious example of green buildings in Palestine is Aqaba Green School. Aqaba green school which was established in Tubas city in 2016, is considered to be the first certified green school in Palestine. It was established with a cost of 1,300,000 USD in accordance with the Palestinian Green Building Guideline.

Based on the literature review regarding green buildings, very limited studies have been carried out on green buildings in Palestine. In spite of the numerous publications and studies worldwide.

2.3 Life Cycle Assessment and Life Cycle Cost

2.3.1 Life Cycle Assessment

The growing awareness of sustainability and the manufacturing operations that drive the conservation of resources led to the need for an environmental assessment tool that provides scientific basis for environmental sustainability (Curran, 2013). What is called Life Cycle Assessment appeared.

Life cycle assessment, or LCA is defined by International Standardization Organization ISO 15686-5(2006) as “a method for evaluating environmental burdens by assessing and measuring energy used in the lifecycle of a building”. Curran (2013, p. 273) identified Life Cycle Assessment as “an analytical tool that captures the overall environmental impacts of a product, process or human activity from raw material acquisition, through production and use, to waste management”.

Life cycle assessment technique is used to assess the environmental performance of a building throughout its life cycle. It also used to compare different design alternatives of a new building (Davis Langdon, 2007). Furthermore, LCA is considered as a tool for assessing the ecological burdens and human health impacts all the stages of products, processes and activities (Klöpffer, 2014).

when making LCA, the results obtained can help designers, engineers and building users in promoting sustainable development in the future in a more logical way (Abd Rashid & Yusoff, 2015).

It must be mentioned that ISO14040 and ISO14044 are relevant international standards for describing the principles and framework for conducting and reporting LCA studies. Therefore, ISO14044 series set up four phases for conducting any LCA study (ISO15686-5, 2008):

1. Goal and scope definition phase: scope includes the system boundary, while the level of LCA depends on the subject and the intended use of the study.

2. Inventory analysis phase: this phase includes the input/output data for the system being studied and the collection of the required data for the achievements of study goals.

3. Impact assessment phase: this phase assesses the product system's life cycle inventory results in order to better understand their environmental significance.

4. Interpretation phase: the final stage where the results of life cycle inventory are summarized and discussed in order to reach out conclusions and recommendations that meet the goal and scope definition.

Each phase in the life cycle assessment has specific standard to be followed. For example: ISO 14040 was developed for principles and framework, ISO 14041 for goal and scope definition and inventory analysis, ISO 14042 for life cycle impact assessment and finally ISO 14043 for interpretation (Davis Langdon, 2007).

Research by Abd Rashid and Yusoff (2015) was conducted to review the LCA methods. The researchers found that LCA implementation can promote sustainability in building industry by mitigating the environmental impacts in the development stage. Also, the research aimed to distinguish materials that significantly affect the environment, and it found that concrete is responsible for the highest embodied energy consumption in buildings. They further argue that building material with lower embodied energy does not necessarily have lower life cycle energy. Moreover Abd Rashid and Yusoff (2015) found that the highest energy consumption in buildings happen in the operation phase.

In a review for several case studies on LCA in the construction industry by Buyle et al. (2012), they found that the LCA methodology has some inherent limitations that should be taken into account when conducting any study such as: the different estimation of lifespan for each case, the difficulty in comparing between cases because of their specific properties (lay-out, climate, and comfort requirements), the isolated approach of environmental issues in construction sector and the difficulty in predicting individual inhabitant behavior, since it is consider as an issue of concern when considering energy consumption.

However, according to Buyle et al.(2012), only a few researchers include both financial and environmental aspects in their research. Therefore and in order to give a more complete picture, economic evaluation such as Life Cycle Costing (LCC) should be taken into consideration along with the environmental evaluation.

2.3.2 Life Cycle Cost

Buildings design was intended to only reduce the initial costs of the buildings, but recently attention is being paid for calculating buildings operating costs too (Davis Langdon, 2007). Therefore, when assessing and evaluating buildings, economic evaluation for buildings should be conducted. Different types of related costs should be taken into consideration such as: initial costs, energy and water costs and replacement costs (Fuller, 2016). For economic evaluation concepts such as: life cycle costing, whole life cycle cost and life cycle cost appeared (ISO15686-5, 2008).

Life cycle costing can be defined as "*a technique for estimating the cost performance and finding if a required project meets the performance requirement*" (ISO15686-5, 2008, p. 6). While whole life cost, WLC, is defined as "*all significant and relevant initial and future costs and benefits of an asset, throughout its life cycle, while fulfilling the performance requirements*" (ISO15686-5, 2008, p. 11).

In recent time, sustainable construction sector has been paying attention to life cycle costing evaluation. However, the application of life cycle costing is still limited in the construction sector due to the misunderstanding of life cycle costing methodology and application (2018a). Besides, according to Kubba (2010), the adoption of life cycle costing approach in the construction sector is still limited due to: issues related to the typical corporate structure that dissociates direct and operating costs, imperfect understanding of the life cycle costing methods and benefits, shortage of needed life cycle cost input data, and the difficulty in calculating performance in comparison to calculating direct cost calculations (Kubba, 2010).

Life-cycle cost analysis can be defined as "*a method for assessing the total cost of facility ownership*" (Fuller, 2016, p. 1). According to Cabeza et al.(2014, p. 5), life cycle cost, LCC, is "an economic evaluation technique for determining the cost of operating and owning a certain asset for a certain period of time".

According to Fuller (2016), minimum life cycle cost is considered to be the easiest measure for economic evaluation, because it aims to estimate the total cost of the project and to choose the optimal design that provides the lowest costs.

Therefore, it is preferable to conduct the life cycle cost analysis at the design stage of the project. LCC can be applied for both small and large facilities (Cabeza et al., 2014). In addition, LCC is useful when having different projects with a need for selecting the one which maximizes net savings, especially if they have the same performance requirements but differ in their initial costs (Fuller, 2016). In order to perform LCC analysis of buildings, ISO15686-5(2008) can provide a clear definition and a common methodology for performing LCC.

According to ISO15686-5(2008), LCC analysis should cover costs over a defined period of analysis that includes the physical, technical, economic or functional life of a building.

Typically, life cycle cost analysis may be used during four key stages of the life cycle of any constructed asset: project investment and planning, design and construction, occupation and finally disposal stage ISO15686-5(2008). At the investment and planning stage, LCC analysis can provide an evaluation of different investment scenarios, While during the design and construction stage, LCC analysis can provide choices between alternative designs for constructed asset and choices among alternative components that have acceptable performance (ISO15686-5, 2008).

According to Kubba (2010), when there is a need for assessing total building cost over time, all costs need to be identified for each year and corresponding amount, and then they must be discounted to present value, and finally added to arrive at the total lifecycle costs for each alternative. According to Kubba (2010) and ISO15686-5(2008), the costs that may be included in LCC analysis are divided into four main categories:

1. Initial design and construction costs: initial costs that may include investment costs for land acquisition, construction and equipment needed to operate a facility (Fuller, 2016).

2. Operating costs: according to ISO15686-5(2008), operating costs usually include energy, water, sewage, waste, recycling, and other utilities. According to Fuller (2016), operational costs are usually assessed for the building as a whole. However, at the design stage it is difficult to predict the energy costs, but they can be obtained from engineering analysis or from computer programs (Fuller, 2016). Energy cost is usually calculated based on its consumption rate and price projection that assumed to increase or decrease at a rate which might be different from general price inflation rate (Fuller, 2016).

According to Dwaikat and Ali (2018a),when conducting energy LCC analysis of a certain building, the total building energy usage (kWh/year) and electricity price tariff ($/kWh) are needed. Furthermore, water cost also can be treated similar to the energy cost, but when calculating the water cost, sewage costs and water usage costs should be taken into consideration (Fuller, 2016). Similar to energy, when conducting water LCC analysis of a certain building, the total building water usage (m^3/year), and water tariff ($/$m^3$) are needed.

3. Maintenance, repair, and replacement costs: According to Reidy et al.(2005), maintenance refers to “the costs incurred to keep the building systems running properly”. Usually, maintenance activities include inspection, monitoring, maintenance planning, testing, repairing and replacements (Davis Langdon, 2007).

According to Fuller (2016), operation, maintenance, and repair costs are difficult to estimate in comparison to other building expenditures. It is important to know that operating and maintenance costs have a high variation from one building to another, even if they are same in age and function (Fuller, 2016).

4. Disposal and end of life costs: disposal costs are “costs associated with disposal of the asset at the end of its life cycle, including taking account of any asset transfer obligations” (ISO15686-5, 2008, p. 2). While, end of life cost is the net cost of disposing assets at the end of their service life or interest period (ISO15686-5, 2008). Typically, these costs include: decommissioning, deconstruction, demolition of a building, recycling, recovery and disposal of materials, and transport costs (ISO15686-5, 2008).

According to the International Standard ISO15686-5(2008), LCC analysis should be conducted using total area of the asset or functional unit or the number of persons accommodated. Accordingly, costs in LCC can be expressed in real or nominal costs, and present or discounted terms.

ISO15686-5(2008) identified nominal costs as costs that are affected by general price inflation or deflation. While real costs as the current value of goods or services that are not affected by general price inflation or deflation. Typically, LCC analysis is preferred to be expressed in real costs rather than nominal costs because of the uncertainty of future values. LCC uses net present value (NPV) concepts, NPV is an economic measure that takes into account discount factors, cash flow, time, etc (ISO15686-5, 2008).

According to ISO15686-5(2008), when conducting a LCC analysis, certain data, costs, elements and components should be taken into consideration. Such as:

1. Building service life
2. Period of analysis
3. Discount rate
4. Inflation or Deflation rate

- Building service life: Building service life is defined by Rauf and Crawford (2015, p. 141) as "*the period of time in which a building is in use*". Also, ISO15686-5 (2008) identified the service life of a building as "*the period during which the asset is intended to be used for its function or business purpose*". Building service life data help in defining the needed type and time to maintain and replace building materials.

However, when increasing the service life of a building, material replacement cycles will increase (Fu et al., 2013). While decreasing buildings service life will cause a more frequent replacement of the whole building, which will increase the demand for the initial embodied energy over a specific period of time (Fu et al., 2013).

A study for investigating the relationship between the service life and the life cycle embodied energy of buildings was conducted by Rauf and Crawford (2015). Rauf and Crawford (2015) calculated the embodied energy for a residential building that having a service life of 1-150years. The study resulted in a reduction of 29% in the life cycle embodied energy for the case study when extending its life by 50-150 years. This indicates that the life cycle embodied energy demand of a building is affected when the building service life variates. Keeping in mind that embodied energy represents the consumed energy during the production of a building, from the acquisition of natural resources to product delivery (Ciravoglu, 2005).

Furthermore, in view of increasing energy prices (Morrissey & Horne, 2011) suggested that 25-40 years' time horizon consider to be significant for the cost savings from higher efficiency standards. Moreover, according to ISO15686-5(2008), the building estimated service life should be at least as long as the design life.

- Period of analysis: ISO15686-5(2008) and Reidy et al.(2005) identified period of analysis as the period of time over which life cycle costs are being analyzed. According to ISO15686-5(2008), the period of analysis may cover the whole life cycle of the assets. But it is recommended not to extend the analysis period over 100 years, because results may become insignificant beyond this period. Accordingly, Heralova (2017) suggested that the length of analyzed period should be 10 to 12 years for private sectors and 25 to 30 years for public ones. However, in order to make a life cycle cost analysis LCCA comparisons valid, the period of analysis must be the same for all alternatives (Reidy et al., 2005).

- Discount rate: Discount rate is the rate that reflects the time value of money (BULL, 2014). When it is used to find the equivalent present value of a future amount of money, then it is called discount rate. But if it is used to convert a current value of money to its equivalence in future value, then it is called interest rate (Jawad & Ozbay, 2006).

Reidy et al.(2005) identified the time value of money as the inequality between the value of money today and the value of the same amount of money to be spent in the future. According to ISO15686-5(2008), discount rate for public sector is determined by the central government. While discount rate for private sector should represent the opportunity cost of investing the capital that may be: the interest cost of a loan for the investment, the interest lost on reduction of cash on deposit, the returns lost on investment, the actual return achieved on capital investment in the business, or the required rate of return of an investor in a new business.

Typically, it is essential to determine a discount rate in conducting a life cycle cost analysis, in order to find the equivalent value for each alternative in a common base date when comparing different investment alternatives (Dwaikat & Ali, 2018a).

According to Reidy et al.(2005), in order to discount future costs to their present value, formula 2.1 is used:

$$PV = \frac{F_Y}{(1+DISC)^Y} \tag{2. 1}$$

Where:

(PV) = the present value (in Year 0)

(F_Y) = the value in the future (in Year Y)

(DISC) = the discount rate.

(Y) = the number of years in the future.

- Inflation / Deflation rate: inflation rate reflects the increment in the general price level of goods and services. In contrast, deflation rate reflects the decrement in the general price level of goods and services (ISO15686-5, 2008).

Inflation rates can be obtained from frequently issued periodic reports by official governmental bodies. Normally, these reports contain data about the consumer price index (CPI) for different types of goods and services (Dwaikat & Ali, 2018a). The consumer price index (CPI) is a measure of the rate of price change through time for goods and services (Statistics Canada, 2012).

The fluctuation related to price of energy has been much higher than the general price inflation (Mirzadeh & Birgisson, 2015). Therefore, the energy price inflation is considered to be an important variable that should be addressed separately from general price inflation when performing life cycle cost analysis (Mirzadeh & Birgisson, 2015).

When using nominal costs in LCC analysis, inflation or deflation factor should be included in the discount rate. On the other hand, inflation or deflation factor should not be included in the discount rate if real costs are used in the analysis (ISO15686-5, 2008).

Since this research is conducted for estimating the energy life cycle cost for public schools in West Bank/Palestine, the previous mentioned LCC elements and components should be taken into account when conducting the analysis of the needed energy life cycle cost baseline in chapter five.

Chapter Three
Methodology

This chapter presents the research methodology that has been adopted in this research. The chapter starts with a discussion of the adopted research philosophy, type, and approach. Then population and sampling process, data collection and data analysis approaches are outlined and discussed. The chapter ends with a brief description of the adopted case study for this research.

3.1 Introduction

According to Saunders et al.(2008), research philosophy means knowledge and its nature development. Therefore, the chosen research philosophy will lead us to assumptions that forms our research strategy and methods. As suggested by Saunders et al.(2008), choosing the appropriate research philosophy and approach depends on the research questions that the researcher wants to answer.

Saunders et al.(2008), mentioned in his book entitled “Research methods for business students” four different types of philosophies: Positivism, Interpretivism, Realism and Pragmatism.

Positivism can be identified as the perspective that argues that reality is stable and can be observed from an objective viewpoint (Saunders et al., 2008). Interpretivism means that humans feelings and beliefs are part of their knowledge. While Realism means what the senses show us as reality is the truth. On the other hand, Pragmatism, which will be adopted in this research, states that mixed methods are appropriate within one study and that the researcher should adopt what is in the interest of his/her research and gives it value. Pragmatism allows the researcher to choose the most suitable research method regardless of his philosophical stands in relation to ontological and epistemological study (Saunders et al., 2008).

Research can be defined according to Kothari (2004) as a scientific and systematic search for relevant information on a specific topic. Kothari (2004) determined four types of researches in his book entitled “Research Methodology: Methods & Techniques”: descriptive vs analytical, applied vs fundamental, qualitative vs quantitative and conceptual vs empirical.

Descriptive research describes the state of affairs as it is at present and researcher can just report what has happened without having control over variables. While analytical research analyzes facts and information that already exist in order to evaluate current situations (Kothari, 2004). Applied research is established to find solutions for immediate problems. While fundamental research, aims to theory formulation (Kothari, 2004). Qualitative research is an exploratory research that is concerned with understanding the underlying reasons and opinions attributed to a social or human problem. Qualitative research is applicable for qualitative phenomena, and the data analysis is inductively building from particular to general themes. Researchers who engage in qualitative research are following the inductive style and focusing on the individual meaning.

While quantitative research relies on measurements of quantity and it used for testing objective theories by analyzing numerical data using statistical methods. Researchers who engage in quantitative research have assumptions about testing theories deductively away from being bias. Also, they can be used to generalize and replicate the findings. Furthermore, Conceptual research depends on abstract ideas. While empirical research, depends on experience or observations only (Kothari, 2004).

These types of research are generated by different types of research approaches and methods, depending on time needed for the research, its purpose of research and the research environment. Research methods such as: questionnaires, interviews, case studies and analysis of historical records and documents can be defined as techniques used for research conduction (Saunders et al., 2008). While according to Saunders et al.(2008), Deduction and Induction are representing two main types of research approaches. In the deduction approach, the researcher first develops theories and hypothesis, then he designs the research strategy. While in induction approach, the researcher first collects data, then he develops appropriate theories depending on the result of the data analysis for his research.

3.2 Research Philosophy

The research philosophy that was adopted in this research is Pragmatism, since Pragmatism argues that the research question is the most important determinant of the adopted research philosophy. Besides, Pragmatism believes that the researcher should study what interests his research and gives it value (Saunders et al., 2008).

Accordingly, Pragmatism applies a practical approach that helps collect and interpret data by integrating different philosophical perspectives. Also it states that mixed methods are appropriate within one study (Saunders et al., 2008).

3.3 Research Type

In order to achieve the objectives of this research, a quantitative research was conducted due to the dependency of this research on the numerical data of the monthly energy consumptions readings for the selected public schools. Furthermore, quantitative research analysis conducted through the use of diagrams and statistics. However, the main advantage of quantitative research is that it is based on meanings derived from numbers and not from the researcher personal judgments (Saunders et al., 2008).

3.4 Research Approach

The research approach that was followed for achieving the research objectives is the deductive approach. According to this approach, the researcher develops a clear theoretical position or conceptual framework before starting with data collection. Then he continues by subsequently testing the theories and ideas that he has already developed using the required data (Saunders et al., 2008).

3.5 Research Method

Research methodology is defined by Kothari (2004) as the logic and sequence of steps used by the researcher to study his research problem. Since the main objective of this research is to estimate the energy life cycle cost of public schools in Palestine, and to quantify the life cycle cost savings associated with reduced energy consumption in Aqqaba green school, the researcher found that the appropriate method to be followed for achieving the research objectives is mixing between the adoption of a case study and survey.

The survey is required in order to collect statistical data to establish an energy consumption baseline for public schools in Palestine, while the case study is required in order to measure the actual energy performance for a green school under operation.

Generally, the methodology that was followed in this research is illustrated in the following steps:

1. Defining the research problem, scope, objectives and questions, then sourcing information from various literature sources such as books, peer reviewed journals, and governmental reports.

2. Selecting the research sample using statistical methods.

3. Starting the data collection process.

4. Editing and tabulating the collected data and performing data analysis.

5. Drawing results and conclusions from the analyzed data.

3.6 Research Population and Sampling

3.6.1 Research Population

Since Aqqaba green school is the first public green school in Palestine, this research population is considered to be all the public sector schools that are located in West Bank/Palestine. Gaza strip has been excluded in this research because of the various obstacles of entering Gaza, the different climate zone of Gaza and the limited time for preparing this research. It is worth mentioning that Aqqaba green school will be taken as a case study for this research.

3.6.2 Research Sampling Methods

In order to measure the actual energy performance of the case study, an energy consumption baseline is required. As mentioned earlier, establishing an energy consumption baseline requires statistical data either from the population or from a statistically representative sample to generalize the findings.

According to Weiss (2011), there are two types of statistics, descriptive and inferential. Descriptive statistics is used for the purpose of summarizing and organizing information. While Inferential Statistics is used for measuring the reliability of conclusions for a certain population depending on the sample information that is obtained from the population.

Therefore, an appropriate method for obtaining a sample from a certain population must be used, in order to ensure that the selected sample can provide conclusions that can be statistically generalized for the entire population.

According to Creswell (2010), there are two types of sampling: Probability and Nonprobability sampling. In probability sampling, a representative sample from the population is selected and the researcher can make generalizations to the population. While in nonprobability sampling, the researcher selects the sample that is already available and that the available sample has the characteristics that the investigator seeks to study. Also, in nonprobability sampling the researcher may not be interested in generalizing findings to a population. According to Creswell (2010), there are two types of nonprobability sampling approaches that can be used: convenience and snowball sampling approaches.

Convenience sampling can be identified according to Creswell (2010, p. 619) as “a *quantitative sampling procedure in which the researcher selects participants because they are willing and available to be studied”.* While, snowball sampling can be identified as “*a sampling procedure in which the researcher asks participants to identify other participants to become members of the sample.”* (Creswell, 2010, p. 628).

On the other hand, according to Weiss (2011), there are different types of probability sampling methods that can be used, such as:

1. Simple Random Sampling: which gives each member of the subset an equal probability of being chosen.

2. Cluster Sampling: which is appropriate when the members of the population are widely scattered geographically. When using Cluster sampling, firstly the population must be divided into clusters, then a simple random sampling of the clusters is obtained. Then all members of the obtained clusters in previous step are considered to be the needed sample. It is worth mentioning that there are two types of cluster sampling, one stage sampling; where all of the elements within selected clusters are included in the sample, and two stage sampling; where a subset of elements within selected clusters is randomly selected for inclusion in the sample.

3. Stratified Sampling: which is more reliable than cluster sampling. When using stratified sampling, firstly the population must be divided into strata, then sampling is done from each stratum (the strata are often sampled in proportion to their size), finally members obtained in previous step will represent the needed sample.

3.6.3 Research Population and Sample Size

Since the main objective of this research is to establish an energy life cycle baseline for public schools in west bank/ Palestine, a random sample of existing public schools from all over the West Bank will be analyzed, in addition to Aqqaba green school as a case study to evaluate the actual performance of this school as a green building against the industry baseline

Also, for accomplishing this research objective, the data about the public schools' location, area, number of students and a time-series data about the actual energy consumptions will be collected from the Statistics and Planning Department of the Palestinian Ministry of Education and the utility service providers.

According to the Palestinian Ministry of Education (2018), Statistics and Planning Department, there are 1825 governmental schools in West Bank distributed over 17 governorates. Therefore, due to time and budget limitations in conducting this research, it is decided to collect data for a statistically representative sample from the population, rather than collecting data for the entire population.

Since public schools in West Bank are already divided into groups (based on their locations) which is compatible with the concept of the Cluster Sampling method, the sample of this research will be selected following the rules of Cluster Sampling method (two stage sampling).

The selection of the research sample using Cluster sampling method is performed as follows:

1. Listing all the public schools in West Bank in clusters (clusters represent governorates) and then selecting the required number of clusters by simple random sampling using random number generator available in MS Excel Professional plus 2016.

2. Performing the second stage of clustering on the elements (schools inside each selected governorate) that are inside the selected clusters by selecting the required number of schools from each selected cluster by simple random sampling using random number generator in MS Excel Professional plus 2016.

Consensus is yet to be reached regarding the sample size in statistics (Weiss, 2012). How large is the required sample size for a certain study is one of the most frequently asked questions in statistics (Naing et al., 2006). In other words, researchers have different opinions of how to determine the appropriate sample size (Bartlett et al., 2001).

According to Ajay & Micah (2014), there are several factors that affect the needed sample size. These factors include: the purpose of the study, population size and level of precision. The level of precision, which is called sampling error, is the range in which the true value of the population is estimated to be. It is recommended to use 5% level of precision. However, according to Naing et al.(2006) if there is a resource limitation, a larger level of precision in case of a preliminary study may be used (e.g. >10%).

Accordingly, Ajay & Micah (2014) suggested that there are different approaches for determining the sample size including:

1. Using a census for small populations: in this approach the entire population is being used as the sample, this approach is applicable for small populations (less than 200). Using census for large populations is considered to be impractical due to costs considerations.

2. Imitating a sample size of similar studies: in this approach the same sample size for similar studies is used. But a risk of repeating errors that were made in determining the sample size of the previous study may occur.

3. Using published tables: in this approach published tables which provide the sample size for a given set of criteria are used. These tables of sample sizes reflect the number of obtained responses. It is important that measured attributes of the sample size follow the normal distribution.

4. Applying formulas to calculate a sample size: sometimes the researcher may need to calculate the necessary sample size for a different combination of levels of precision, confidence, and variability using a certain formula.

According to Cochran (1963), in order to yield a representative sample for proportions in large populations Equation 3.1 can be used:

$$n_0 = \frac{Z^2pq}{e^2} \tag{3. 1}$$

Where:

(n_0) = the sample size.

(Z^2) = the abscissa of the normal curve that cuts off an area α at the tails (1 - α equals the desired confidence level).

(e) = the desired level of precision.

(p) = the estimated proportion of an attribute that is present in the population

(q) = 1-p.

The previous formula can be implemented when the data has a normal distribution.

In this research, the researcher decided to use “Thompson formula” (Equation 3.2) for obtaining a representative sample. The size of population following Thompson formula is given by (Thompson, 2012):

$$n = \frac{NP(1-P)}{((N-1)(d^2/_{Z^2}))+P(1-P)} \qquad (3.2)$$

Where:

(n) = the required sample size.

(N) = the total number of populations. (1825 school)

(d) = the percentage error. (0.10)

(p) = estimated proportion of property offers and neutrals. (0.50)

(Z) = the upper α/2 of the normal distribution curve. (1.96 for 95% confidence level).

Furthermore, according to the central limit theorem that states *"that for a large sample size, the possible sample means are approximately normally distributed, regardless of the distribution of the variable under consideration*" (Weiss, 2011, p:293), which conclude that the sample size should be equal or higher than 30 regardless of the distribution of the variable under consideration in order to be considered large enough (Weiss, 2011).

However, for obtaining a representative sample size of population for this research and in order to generalize the results over the population, the researcher decided to use Thompson formula for determining the required sample size, as can be seen in chapter 4, section 4.1. And then using Cluster sampling method for selecting the needed sample as mentioned earlier in this section.

3.7 Data Collection Approach

In data collection phase, the needed data for this research was collected from the Ministry of Education in Ramallah city, utility service providers, and Municipalities.

For the purpose of answering the research questions, the following types of data were collected:

- Historical records of energy consumption data for selected public schools were gathered from the utility service providers: Jerusalem District Electricity company in Ramallah city and Northern Electricity Distribution company in Nablus city. The collected energy consumption data for public schools covered a period of five years (2014-2018) for each school, because of the policies of the utility service providers that prevent revealing data for more than five years.

- The monthly energy consumption reports of Aqqaba green school were gathered from the Municipality of Tubas city, in addition to Aqqaba green school photovoltaic (PV) system data.

- Data about the schools' names, locations, areas, number of students and gender in each selected school were collected from the Ministry of Education in Ramallah city.

- Historical records of energy price changes in Palestine were gathered from the Palestinian Electricity Regulatory Council, Jerusalem District Electricity company and Northern Electricity Distribution company.

More detailed discussion and description of the collected data is presented in the next chapter (chapter four).

3.8 Data Analysis Approach

For the purpose of establishing the energy life cycle baseline for the public schools in West Bank /Palestine, the following approach for analyzing the data will be followed:

1. The monthly consumption data for each school in the selected sample will be converted to annual consumption for the purpose of reducing the variation in the monthly consumption data.

2. The average of the annual consumption data for each school (that was available for the five years period from 2014 to 2018) will be calculated to obtain the average annual energy consumption for each school in the selected sample.

3. The schools that are provided with PV-systems will be excluded from the analysis due to the unavailability of their energy consumption and energy generated data.

4. The average annual energy consumption data will be ordered in an ascending order for calculating the annual energy consumption outliers for the selected sample. The annual energy consumption outliers will be identified by performing the five-number summary analysis (min, Q1, median, Q3, max) in order to calculate the interquartile range (IQR).

5. After identifying the outliers of the annual energy consumption data and excluding the schools that have PV-systems, the sample arithmetic

mean of the annual energy consumption will be calculated by dividing the sum of the average annual energy consumption for the sample over the sample size.

6. The cost of the average annual energy consumptions will be calculated by multiplying the mean of the annual energy consumption with the electricity price tariff.

7. The electricity price inflation rate in Palestine will be calculated using the historical records of the annual change in electricity prices in Palestine that are available for the years 2011 to 2018. The inflation rate will be calculated by subtracting the current electricity price (A) from the original electricity price (B) and then divide the result by the original electricity price (B): ((B-A)/B) *100%.

8. After defining the inflation rate, interest rate, and the period of analysis, the energy life cycle cost analysis will be performed to obtain the required baseline using Equation 3.3 (ISO15686-5, 2008):

$$F = P(1 + e)^n \tag{3. 3}$$

Where:

(F) = future value (nominal cost).

(P) = cost in the base year.

(e) = expected percentage of annual cost increase.

(n) = number of years between the base year and the occurrence of the cost.

3.9 Research Case Study Description

In this research, estimating the life cycle cost of energy consumption in public schools will help in determining the size of savings associated with reduced energy consumption in green schools compared to conventional ones in West Bank/Palestine. Since Aqqaba green school is considered to be the first green school in Palestine, it was taken as a case study for this research.

Aqqaba secondary school for girls which, established in Tubas/Nablus city in 2016 with a cost of USD 1,300,000, is the first green school in Palestine to be implemented according to the Palestinian Green Building Guide that was launched in 2013 (Global Communities, 2016). The Green Building Guide provided a clear rating system for the classification of green buildings with six categories that must be available in the project to be considered green.

These six categories include site sustainability, energy efficiency, water efficiency, quality of internal environment, quality of use of materials and resources and creative ideas and integrated design of the building (Hijleh, 2017).

Aqqaba school has a built area of 1,500 m^2 distributed as follow: 8 classrooms, library, two laboratories, play and green areas. In addition, it has 3 water wells, recycling system for grey water and solar panels for electricity generation. Figure 3.1 below shows the first-floor plan of Aqqaba green school with the green areas and entrances (Global Communities, 2016).

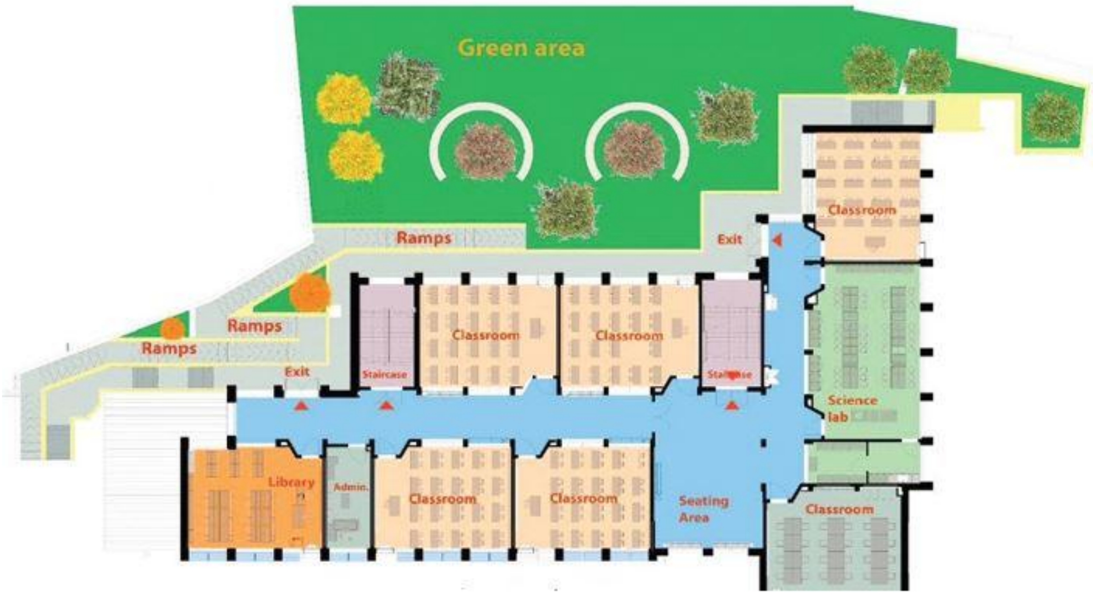

Figure 3.1: Aqqaba green school first-floor plan with the green areas and entrances.

According to the Electricity Department in the Municipality of Tubas city, Aqqaba green school is supplied with a 15 kWp capacity photovoltaic (PV) system. It is a grid-connected system that connected to the main grid. This means that while the green school is being supplied with the total energy demand from the utility service provider, the whole generated energy by the PV-system is being exported to the grid that is operated by the utility service provider. At the end of each month, an officer from the utility service provider records the energy consumption meter and energy generation meter readings. The total energy consumption readings are being subtracted from the total net generated energy at the end of each year. If there is a surplus of energy then the utility services provider credits

75% of it to the green school's account at the local electricity tariff. Figure 3.2 below shows Aqqaba green school PV-system solar panels photograph.

Figure 3.2: Photograph of the solar panels for Aqqaba green school PV-system.

3.10 Chapter Summery

This chapter presented the research design. The researcher adopts pragmatism as the research philosophy which represents the researchers stand and perspective concerning the epistemological studies. This, allowed the researcher to design a mixed-method research approach where survey and case study as research strategies were adopted.

The research can be classified as quantitative research as it is based on numerical data which is collected and analyzed following quantitative methods.

In the subsequent chapters (Chapter 4 and 5) more detailed discussion about the data collection and analysis process is presented.

Chapter Four
Data Collection

This chapter presents the data collection process and the collected data that is needed to achieve the objectives of the research. Research population and sampling procedure are discussed in this chapter. The chapter discusses the different types of data that have been collected for the purpose of achieving the research objectives.

4.1 Research Population and Sampling

In this research, the population was essential to be identified in order to establish the energy life cycle cost baseline for public schools in West Bank/Palestine. Accordingly, the population in this research consists of all public schools that are located in West Bank/Palestine.

Therefore, the Statistics and Planning Department in the Palestinian Ministry of Education was contacted to obtain the total number of public schools that are in use in West Bank. According to Statistics and Planning Department of Palestinian Ministry of Education (2018), there are 1825 public schools under operation in West Bank. These schools are distributed over 17 governorates as shown in Table 4.1.

Table 4.1: The distribution of public schools in West Bank/Palestine according to governorate.

	Governorate	**Number of schools**		**Governorate**	**Number of schools**		**Governorate**	**Number of schools**
1	Ramallah	196	7	Bethlehem	133	13	Jerusalem suburbs	74
2	Nablus	180	8	North Hebron	104	14	Salfit	73
3	South Hebron	164	9	Qabatya	91	15	Jerusalem	51
4	Jenin	154	10	Yatta	85	16	Tubas	45
5	Hebron	153	11	South Nablus	82	17	Jericho	22
6	Tulkarm	138	12	Qalqilya	80			

Accordingly, a statistically representative random sample of public schools from the population was selected using Cluster Sampling method (two stage sampling). Cluster sampling is a recommended sampling technique for cases in which the population is widely spread out geographically (Weiss, 2012). As discussed earlier in Chapter three section 3.6.3, Thompson formula (Equation 3.2, in Chapter 3) is adopted to determine the sample size. Equation 3.2 gives a sample size of 91 schools as the required sample size of the population considering an error of 10%.

The following steps explain how the two stage Cluster sampling method was used for selecting the required sample:

- Step 1: the researcher divided the schools into groups/clusters according to their geographical locations and governorates. Since the public schools in West Bank are distributed all over 17 governorates, each governorate was considered as a cluster where the total number of schools in each cluster is known (see Table 4.1 above)

- Step 2: a simple random sample, using random number generator available in MS Excel Professional Plus 2016, from the 17 clusters (governorates) was obtained. The randomly selected clusters for this research were Nablus and Ramallah governorates. Since the two selected governorates have similar climate, a third governorate with different climate characteristics (Jenin governorate) was intentionally selected and added to the randomly selected clusters in order to increase the representativeness of the sample.

- Step 3: the elements (schools) inside each selected cluster (Nablus, Ramallah and Jenin) were also sampled by the same simple random sampling technique used in step 1 in order to obtain the calculated minimum sample size of 91 schools as mentioned earlier. For each selected governorate the number of needed schools was determined by:

A. Calculating the total number of schools that are located in Nablus, Ramallah and Jenin governorates (180+196+154= 530 school) respectively.

B. Then determining the needed sample size ratio of each governorate {Nablus: (180/530) *100% = 33.96%, Ramallah: (196/530) *100%=36.98%, Jenin: (154/530) *100%=29.06%)}.

C. Then multiplying the ratio of each governorate by the required research sample size in order to determine the needed number of schools from each governorate {Nablus:33.96%*91=30.90=31 schools, Ramallah: 36.98%*91=33.65=34 schools, Jenin: 29.06%*91= 26.44= 27 schools}.

The selected research sample size must contain at least 31 schools from Nablus governorate, 34 schools from Ramallah governorate and 27 schools from Jenin governorate. Accordingly, the number of schools that were selected from each randomly selected governorate was as follow: Nablus governorate 37 schools, Ramallah governorate 47 schools and Jenin governorate 30 schools. It is worth mentioning that the increase in the number of selected schools from each governorate was due to the availability of their data.

In total, 114 school were selected which is about 25% higher than the calculated minimum sample size of 91 schools as calculated earlier using Thompson rule. See Tables 4.2, 4.3, 4.4 for the selected schools in Nablus, Ramallah and Jenin governorates.

Table 4.2: Selected schools sample from Nablus governorate.

Nablus governorate					
	School name		**School name**		**School name**
1	Imam Shafi'i elementary school for girls	14	Al-Itihad elementary boys school	27	Ruhi Alhindi elementary boys school/Tel
2	Samir Saad Eddin secondary school for girls	15	Abdul Rahim Jardaneh secondary boys school	28	Zeinabia elementary school for girls
3	Abdulmagith Al-Ansari elementary boys school	16	Jamal Al-Masri elementary girls school	29	Omar Al-Mukhtar elementary girls school
4	Khadija om Al-Mouminine mixed elementary school	17	Qusin secondary school for girls	30	Haj Mohammed Ali Qarman elementary school for boys
5	Yousef Al-Barqawi elementary boys school	18	Alnizamia (B) elementary school for girls	31	Mohammed bin Rashid Al-Maktoum elementary boys school
6	IRAQ AL-Tayah secondary girls school	19	Yasser Arafat secondary girls school	32	Aisha secondary school for girls
7	Zeinabiyeh elementary boys school	20	Fatimiya secondary school for girls	33	Saeed Bin Amer secondary school for girls
8	Khansa elementary girls school	21	Kfarqaleel secondary school for girls	34	Muscat mixed secondary school / Bayt Iba
9	Yasid secondary school for girls	22	Saad bin Abi-Waqas elementary mixed school	35	Deir El-Hatab elementary school for boys/ Salem

10	Azmout elementary girls school	23	Alnizamia (A) elementary school for girls	36	Carmel secondary school for girls
11	Kamal Jumblatt secondary school for girls	24	Burhan Kamal elementary school for boys	37	Talouzeh secondary mixed school
12	Azmout secondary boys school	25	Zafer Al-Masri secondary school for girls		
13	Abn-Seena elementary girls school	26	Bassam Shakaa elementary school for boys		

Table 4.3: Selected schools sample from Ramallah governorate.

Ramallah governorate					
	School name		**School name**		**School name**
1	Almazraa Alqablia secondary boys school	17	Singel elementary girls school	33	Shuqba mixed elementary school
2	Mashhour Haditha El Jazy secondary girls school	18	Sorda mixed elementary school	34	Majida and Seela girls secondary school

Table 4.3: (continued)

	School name		**School name**		**School name**
3	shuhada Silwad secondary school for boys	19	Burqa secondary mixed school	35	Deir Ammar secondary girls school
4	Saffa elementary boys school	20	Deir Abu Mishaal secondary girls school	36	Singel High elementary males school
5	Al-Tirah mixed secondary school	21	Jalgilia mixed elementary school	37	Al-Janiah mixed secondary school
6	Abwain secondary mixed school	22	Shabtin secondary mixed school	38	Kfar Naama secondary mixed school
7	Alberah New secondary girls school	23	Abu Obeida elementary girls school	39	Aziz Shaheen secondary girls school
8	Petunia secondary girls school	24	Kubar elementary boys school	40	Spanish elementary mixed school
9	Ni'lin secondary boys school	25	Deir-Greer secondary boys school	41	Al-labban Algharbi secondary males school
10	Bil'in secondary girls school	26	Ain-Munjed elementary school for boys	42	Rantis secondary girls school
11	Mughtaribi Alberah elementary mixed school	27	Qarawah secondary girls school	43	Turmus'ayya secondary school
12	Birzeit High elementary boys school	28	Kharbatha Bani Harith secondary girls school	44	Abu Qash elementary school for boys

13	Betaine secondary boys school	29	Kubar secondary girls school	45	Almughir secondary boys school
14	Ras Karkar secondary mixed school	30	Almazraa Alqablia mixed elementary school	46	Abu Shkhaidem girls secondary school
15	Ain Yabroud mixed elementary school	31	Abu Falah secondary school for boys	47	Kharbatha Bani Harith elementary mixed school
16	Beitlo secondary mixed school	32	Alfajr Al-jadid mixed elementary school		

Table 4.4: Selected schools sample from Jenin governorate.

Jenin governorate					
	School name		**School name**		**School name**
1	Alshahida Muntaha Hourani elementary school for girls	11	Alshahida Kadoura Moussa elementary school for girls	21	Al-Ibrahimin secondary girls school
2	Jenin secondary school for boys	12	Malaysian Friendship secondary school for girls	22	Walid Abu Mowais elementary girls school
3	Yamoun secondary school for boys	13	Al-Zahraa secondary school for girls	23	Al-Salhin elementary boys school

Table 4.4: (continued)

	School name		**School name**		**School name**
4	Nusseibeh Almaznieh elementary school for girls	14	Haifa elementary school for girls	24	Mohammad Arshid Yassin Elementary Boys School
5	Alshahid Salah Khalaf elementary school for boys	15	Yamoun secondary school for girls	25	Anin elementary girls school
6	Jenin Industrial secondary school	16	Banat Shuhadaa Al-Yamoun elementary school for girls	26	Kfardan elementary girls school
7	Hitteen secondary school for boys	17	Al-Malaysia elementary school for girls	27	Sumaya Bint Al Khayat Elementary girls school (Al Yamoun)
8	Hitteen elementary school for boys	18	Amna Bint Wahab school for girls	28	Kafr Dan elementary school for boys
9	Qasem Mohammed Qasem elementary mixed school	19	Al-Zahra elementary girls school	29	Anin secondary school for boys
10	Al-Salam secondary school for boys	20	Palestinian - Turkish Friendship girls school	30	Bilal Al-Awsat elementary boys school

The local office of Ministry of Education in Jenin provided the researcher with a list of schools located in Jenin city which are supplied with electricity from Northern Electricity Distribution company in Nablus where official records are available. This was essential in order to obtain official electricity consumption records from monthly bills.

This was required as most schools in Jenin are supplied with electricity by local cooperatives free of charge. As such, there are no available records for the energy demands/ consumptions of most schools in Jenin.

Therefore, schools in Jenin city sample were reselected based on the schools list that was obtained from the Ministry of Education in Jenin.

In summary, the minimum required sample size for this research was calculated using Thompson formula (Equation 3.2, Chapter 3) The minimum sample size required to establish the energy consumption baseline is 91 schools. A total of 114 public schools was selected which is considered to be enough for generalizing the research results over the population.

As a result, the sample size which is used to establish the energy consumption baseline is114 public school distributed over three clusters (governorate) which are: Nablus, Ramallah and Jenin.

4. 2 Collected Data for the Sample

For accomplishing the research objectives, a time-series data and historical records for the actual energy consumptions in conventional schools were obtained from the utility service providers: Jerusalem District Electricity company in Ramallah city and Northern Electricity Distribution company in Nablus city.

The utility service providers keep historical records for energy consumption for a long period of time. However, it is decided to limit the time horizon of the data for the past five years (2014 – 2018) for two main reasons: the first reason is that the policy of the utility service providers prevents revealing data for more than five years as mentioned earlier in Chapter 3, section 3.7. The second reason is that limiting the data to the past five years assists in establishing a more accurate energy consumption baseline as the data reflects a relatively recent energy consumption pattern in schools.

Accordingly, the monthly electricity consumption data for the past five years (2014 to 2018) for each school in the selected sample was converted to annual consumption. This eliminates the monthly variation and recording error that might occur by meter readers. Then the average annual electricity consumption for the selected five years data for each school was calculated and tabulated using MS Excel Professional Plus 2016 sheets. Table 4.5 below shows the average annual electricity consumption for each selected school in the sample.

It is worth mentioning that the electricity consumption data that were collected from Jerusalem District Electricity company were having a cumulative reading. In other words, a monthly reading of the monthly consumption was not recorded, instead a cumulative reading was only available. Therefore, to obtain the energy consumption for each month for Ramallah schools sample the researcher calculated the electricity consumption for each month from the given data. On the other hand, the electricity consumption data that were collected from Northern Electricity Distribution Company had monthly consumption readings. For reviewing the energy consumption raw data of Nablus and Jenin schools, see Appendix A.

It must be mentioned that, some schools in the selected sample were established after year 2014, therefore the energy consumption data for these schools were available for a period less than five years. Due to the unavailability of the full five years' electricity consumption data for some schools in the selected sample, the average annual energy consumption for these schools was calculated by dividing each school's total energy consumption over its occupancy period. In Table 4.5 below, the schools' names that were marked with an asterisk (*) represent these with electricity consumption data for less than five years.

Among the sample, there are eleven schools from the 114 schools which represent the sample having a photo voltaic (PV) system for generating energy. These eleven schools were excluded from the selected sample before starting the analysis due to the unavailability of their PV-systems technical data and their energy consumption detailed data. In Table 4.5 below, the schools that are marked with double asterisks (**) represent the schools that are provided with PV-systems and were excluded.

In addition to energy consumption, the collected data from the Statistics and Planning Department of the Palestinian Ministry of Education for the sample includes: school area, number of students, and gender as shown in Table 4.5.

Table 4.5: Collected data for the sample

	School Name	Region	Gender	Number of Males	Number of Females	Total Number of Students	School Building Area(m^2)	Yards and Playgrounds Area(m^2)	Shaded Places Area(m^2)	Average Annual Electricity Consumption (kWh/year)	Building Energy Index per Meter Square (kWh/m²/year)
1	Imam Shafi'i Elementary School for Girls	Nablus	Females	-	74.00	74.00	253.00	67.00	30.00	3,854.40	15.23
2	Samir Saad Eddin Secondary School for Girls	Nablus	Females	-	574.00	574.00	2,546.00	2,800.00	94.50	14,467.80	5.68
3	Abdulmagith Al - Ansari Elementary Boys	Nablus	Males	247.00	-	247.00	1,625.00	1,244.00	60.00	7,513.60	4.62
4	Khadija om Al-Mouminine Mixed Elementary School	Nablus	Mixed	82.00	82.00	164.00	323.00	133.00	133.00	3,960.20	12.26
5	Yousef Al - Barqawi Elementary Boys School	Nablus	Males	100.00	-	100.00	598.00	100.00	-	5,394.20	9.02
6	IRAQ AL-Tayah Secondary Girls School	Nablus	Females	-	435.00	435.00	2,064.00	593.00	24.00	11,048.80	5.35
7	Zeinabiyeh Elementary Boys School	Nablus	Males	70.00	-	70.00	200.00	200.00	-	2,948.60	14.74
8	Khansa Elementary Girls School	Nablus	Females	-	486.00	486.00	368.00	533.00	46.00	4,459.20	12.12
9	Yasid Secondary School for Girls	Nablus	Females	-	284.00	284.00	1,250.00	400.00	25.00	4,096.80	3.28

	School Name	Region	Gender	Number of Males	Number of Females	Total Number of Students	School Building Area(m^2)	Yards and Playgrounds Area(m^2)	Shaded Places Area(m^2)	Average Annual Electricity Consumption (kWh/year)	Building Energy Index per Meter Square (kWh/m^2/year)
10	Azmout Elementary Girls School	Nablus	Females	-	154.00	154.00	450.00	750.00	1,124.00	2,903.60	6.45
11	Kamal Jumblatt Secondary School for Girls	Nablus	Females	-	527.00	527.00	3,025.00	1,245.00	513.00	12,384.80	4.09
12	Azmout Secondary Boys School	Nablus	Males	440.00	-	440.00	1,892.00	1,444.00	62.00	4,585.60	2.42
13	Abn-Seena Elementary Girls School	Nablus	Females	-	161.00	161.00	640.00	1,200.00	11.00	5,672.60	8.86
14	Al-itihad Elementary Boys School	Nablus	Males	215.00	-	215.00	965.00	1,800.00	25.00	3,657.20	3.79
15	Abdul Rahim Jardaneh Secondary Boys School	Nablus	Males	464.00	-	464.00	1,453.00	582.00	30.00	10,060.40	6.92
16	Jamal Al - Masri Elementary Girls School	Nablus	Females	-	399.00	399.00	1,747.00	955.00	126.00	13,857.20	7.93
17	Qusin Secondary School for Girls	Nablus	Females	-	206.00	206.00	504.00	556.00	90.00	6,667.60	13.23
18	Alnizamia B Elementary School for Girls	Nablus	Females	-	154.00	154.00	1,000.00	429.00	58.00	3,791.60	3.79
19	Yasser Arafat Secondary Girls School	Nablus	Females	-	572.00	572.00	5,000.00	1,000.00	50.00	15,873.20	3.17
20	Fatimiya Secondary School for Girls	Nablus	Females	-	331.00	331.00	1,970.00	700.00	40.00	11,540.00	5.86

	School Name	Region	Gender	Number of Males	Number of Females	Total Number of Students	School Building Area(m^2)	Yards and Playgrounds Area(m^2)	Shaded Places Area(m^2)	Average Annual Electricity Consumption (kWh/year)	Building Energy Index per Meter Square (kWh/m²/year)
21	Kfarqaleel Secondary School for Girls	Nablus	Females	-	340.00	340.00	505.00	440.00	100.00	4,754.40	9.41
22	Saad bin Abi Waqas Elementary Mixed School	Nablus	Mixed	122.00	131.00	253.00	723.00	195.00	-	9,581.00	13.25
23	Alnizamia A Elementary School for girls	Nablus	Females	-	65.00	65.00	330.00	500.00	30.00	5,350.80	16.21
24	Burhan Kamal Elementary School for Boys	Nablus	Males	158.00	-	158.00	1,092.00	1,433.00	112.00	7,143.60	6.54
25	Zafer Al Masri Secondary School for Girls	Nablus	Females	-	275.00	275.00	1,225.00	1,444.00	-	12,295.80	10.04
26	Bassam Shakaa Elementary School for Boys	Nablus	Males	715.00	-	715.00	1,700.00	700.00	12.00	10,860.80	6.39
27	Ruhi Alhindi Elementary Boys School/Tel	Nablus	Males	140.00	-	140.00	1,300.00	3,000.00	28.00	4,837.60	3.72
28	Zeinabia Elementary School for Girls	Nablus	Females	-	52.00	52.00	500.00	160.00	-	3,226.00	6.45
29	Omar Al - Mukhtar Elementary Girls School	Nablus	Females	-	260.00	260.00	908.00	300.00	-	6,777.20	7.46
30	Haj Mohammed Ali Qarman Elementary School for Boys	Nablus	Males	427.00	-	427.00	2,150.00	750.00	-	16,458.00	7.65

	School Name	Region	Gender	Number of Males	Number of Females	Total Number of Students	School Building Area(m^2)	Yards and Playgrounds Area(m^2)	Shaded Places Area(m^2)	Average Annual Electricity Consumption (kWh/year)	Building Energy Index per Meter Square (kWh/m²/year)
31	Mohammed bin Rashid Al Maktoum Elementary Boys Est	Nablus	Males	193.00	-	193.00	2,640.00	1,500.00	-	5,327.20	2.02
32	Aisha Secondary School for Girls	Nablus	Females	-	474.00	474.00	1,140.00	1,770.00	20.00	10,215.00	8.96
33	Saeed Bin Amer Secondary School for Girls	Nablus	Females	-	256.00	256.00	1,510.00	1,200.00	-	9,923.80	6.57
34	Muscat Mixed Secondary School / Bayt Iba	Nablus	Mixed	245.00	42.00	287.00	2,046.00	1,950.00	50.00	11,190.00	5.47
35	Deir El-Hatab Elementary School for Boys/ Salem	Nablus	Males	627.00	-	627.00	1,845.00	1,715.00	-	10,619.20	5.76
36	Carmel Secondary School for Girls	Nablus	Females	-	282.00	282.00	1,680.00	200.00	40.00	6,219.00	3.70
37	Talouzeh Secondary Mixed School	Nablus	Mixed	230.00	18.00	248.00	1,400.00	1,040.00	-	7,127.80	5.09
38	Alshahida Muntaha Hourani Elementary School for Girls	Jenin	Females	-	223.00	223.00	1,000.00	1,500.00	-	5,604.20	5.60
39	Jenin Secondary School for Boys	Jenin	Males	311.00	-	311.00	1,050.00	582.00	250.00	12,519.60	11.92
40	Yamoun Secondary School for Boys	Jenin	Males	346.00	-	346.00	3,000.00	1,000.00	100.00	19,269.40	6.42
41	Nusseibeh Almaznieh Elementary School for Girls	Jenin	Females	-	398.00	398.00	1,570.00	150.00	150.00	10,579.40	6.74

	School Name	Region	Gender	Number of Males	Number of Females	Total Number of Students	School Building Area(m^2)	Yards and Playgrounds Area(m^2)	Shaded Places Area(m^2)	Average Annual Electricity Consumption (kWh/year)	Building Energy Index per Meter Square (kWh/m²/year)
42	Alshahid Salah Khalaf Elementary school for Boys	Jenin	Males	171.00	-	171.00	380.00	200.00	100.00	2,597.80	6.84
43	Jenin Industrial Secondary School***	Jenin	Males	275.00	-	275.00	3,310.00	3,300.00	-	40,344.40	12.19
44	Hitteen Secondary School for Boys	Jenin	Males	239.00	-	239.00	780.00	883.00	-	10,727.60	13.75
45	Hitteen Elementary School for Boys	Jenin	Males	569.00	-	569.00	2,100.00	3,080.00	90.00	11,748.20	5.59
46	Qasem Mohammed Qasem Elementary Mixed School*	Jenin	Mixed	82.00	152.00	234.00	1,100.00	1,000.00	250.00	7,455.50	6.78
47	Al-Salam Secondary School for Boys	Jenin	Males	292.00	-	292.00	1,272.00	1,905.00	232.00	14,184.80	11.15
48	Alshahida Kadoura Moussa Elementary School for Girls	Jenin	Females	-	362.00	362.00	1,434.70	1,200.00	300.00	9,501.60	6.62
49	Malaysian Friendship Secondary School for Girls	Jenin	Mixed	74.00	313.00	387.00	1,698.00	2,334.00	120.00	13,941.40	8.21
50	Al - Zahraa Secondary School for Girls	Jenin	Females	-	454.00	454.00	2,100.00	1,800.00	100.00	15,242.20	7.26
51	Haifa Elementary school for Girls	Jenin	Females	-	329.00	329.00	1,720.00	700.00	169.00	5,550.40	3.23
52	Yamoun Secondary School for Girls	Jenin	Females	-	505.00	505.00	2,000.00	1,200.00	150.00	14,982.80	7.49

	School Name	Region	Gender	Number of Males	Number of Females	Total Number of Students	School Building Area(m^2)	Yards and Playgrounds Area(m^2)	Shaded Places Area(m^2)	Average Annual Electricity Consumption (kWh/year)	Building Energy Index per Meter Square (kWh/m²/year)
53	Banat Shuhadaa Al-Yamoun Elementary school for Girls	Jenin	Females	-	91.00	91.00	300.00	666.00	-	13,817.00	46.06
54	Al-Malaysia Elementary School for Girls	Jenin	Mixed	120.00	339.00	459.00	2,250.00	2,250.00	150.00	9,943.80	4.42
55	Amna Bint Wahab School for Girls*	Jenin	Females	-	572.00	572.00	2,499.00	2,000.00	-	11,432.33	4.57
56	Al-Zahra Elementary Girls School	Jenin	Females	-	531.00	531.00	864.00	460.00	200.00	21,957.60	25.41
57	Palestinian - Turkish Friendship Girls School	Jenin	Mixed	73.00	349.00	422.00	1,740.00	495.00	200.00	8,412.00	4.83
58	Al - Ibrahimin Secondary Girls School	Jenin	Females	-	427.00	427.00	1,677.00	1,187.00	-	11,375.20	6.78
59	Walid Abu Mowais Elementary Girls School	Jenin	Females	-	406.00	406.00	1,364.00	1,364.00	-	13,050.20	9.57
60	Al-Salhin Elementary Boys School	Jenin	Males	385.00	-	385.00	2,784.00	1,800.00	70.00	10,840.60	3.89
61	Mohammad Arshid Yassin Elementary Boys School	Jenin	Males	301.00	-	301.00	1,700.00	3,000.00	200.00	5,261.80	3.10
62	Anin Elementary Girls School	Jenin	Females	-	259.00	259.00	1,630.00	700.00	24.00	3,975.20	2.44
63	Kfardan Elementary Girls School	Jenin	Females	-	582.00	582.00	3,000.00	2,000.00	180.00	14,570.20	4.86

	School Name	Region	Gender	Number of Males	Number of Females	Total Number of Students	School Building Area(m^2)	Yards and Playgrounds Area(m^2)	Shaded Places Area(m^2)	Average Annual Electricity Consumption (kWh/year)	Building Energy Index per Meter Square (kWh/m²/year)
64	Sumaya Bint Al Khayat Elementary Girls School (Al Yamoun)	Jenin	Females	-	510.00	510.00	2,415.00	420.00	72.00	13,817.00	5.72
65	Kafr Dan Elementary School for Boys	Jenin	Males	371.00	-	371.00	1,106.00	787.00	117.00	4,525.00	4.09
66	Anin Secondary School For Boys**	Jenin	Males	218.00	-	218.00	1,000.00	1,000.00	70.00	6,816.80	-
67	Bilal Al - Awsat Elementary Boys School**	Jenin	Males	506.00	-	506.00	1,665.00	2,445.00	397.00	15,148.80	9.10
68	Almazraa Alqablia Secondary Boys School	Ramallah	Males	74.00	-	74.00	1,675.00	3,456.00	114.00	4,071.50	2.43
69	Mashhour Haditha El Jazy Secondary Girls School*	Ramallah	Females	-	254.00	254.00	2,281.00	3,100.00	150.00	9,883.50	4.33
70	shuhada Silwad Secondary School for Boys	Ramallah	Males	457.00	-	457.00	2,637.00	2.88	-	11,173.80	4.24
71	Saffa Elementary boys School	Ramallah	Males	238.00	-	238.00	1,000.00	600.00	200.00	10,150.80	10.15
72	Al-Tirah Mixed secondary School	Ramallah	Mixed	60.00	195.00	255.00	1,337.22	691.00	52.00	8,402.60	6.28
73	Abwain Secondary Mixed School	Ramallah	Mixed	296.00	24.00	320.00	1,480.00	3,375.00	-	6,639.80	4.49

	School Name	Region	Gender	Number of Males	Number of Females	Total Number of Students	School Building Area(m^2)	Yards and Playgrounds Area(m^2)	Shaded Places Area(m^2)	Average Annual Electricity Consumption (kWh/year)	Building Energy Index per Meter Square (kWh/m²/year)
74	Alberah New Secondary Girls School*	Ramallah	Females	-	554.00	554.00	3,600.00	2,870.00	500.00	20,258.33	5.63
75	Petunia Secondary Girls School	Ramallah	Females	-	408.00	408.00	700.00	1,100.00	-	14,306.00	20.44
76	Ni'lin Secondary Boys School	Ramallah	Males	406.00	-	406.00	1,753.00	3,507.00	30.00	13,118.00	7.48
77	Bil'in Secondary Girls School	Ramallah	Females	-	245.00	245.00	1,640.00	4,509.00	22.00	11,352.60	6.92
78	Mughtaribi Alberah mixed basic beer	Ramallah	Mixed	154.00	179.00	333.00	2,634.00	2,480.00	65.00	11,206.60	4.25
79	Birzeit High Elementary Boys School	Ramallah	Males	316.00	-	316.00	1,765.16	2,818.00	100.00	14,989.60	8.49
80	Betaine Secondary Boys School	Ramallah	Males	178.00	-	178.00	564.00	1,967.00	-	6,253.40	11.09
81	Ras Karkar Secondary Mixed School	Ramallah	Mixed	86.00	252.00	338.00	2,197.00	2,619.00	49.00	12,248.00	5.57
82	Ain Yabroud Mixed Elementary School	Ramallah	Mixed	80.00	103.00	183.00	600.00	600.00	50.00	7,214.60	12.02
83	Beitlo Secondary Mixed School	Ramallah	Mixed	370.00	37.00	407.00	1,630.00	4,530.00	50.00	8,154.80	5.00
84	singel Elementary Girls School	Ramallah	Females	-	249.00	249.00	1,000.00	1,010.00	40.00	12,250.40	12.25

	School Name	Region	Gender	Number of Males	Number of Females	Total Number of Students	School Building Area(m^2)	Yards and Playgrounds Area(m^2)	Shaded Places Area(m^2)	Average Annual Electricity Consumption (kWh/year)	Building Energy Index per Meter Square (kWh/m²/year)
85	Sorda Mixed Elementary School	Ramallah	Mixed	86.00	82.00	168.00	1,114.00	500.00	115.00	6,181.80	5.55
86	Burqa Secondary Mixed School	Ramallah	Mixed	188.00	18.00	206.00	600.00	1,414.00	-	10,226.00	17.04
87	Deir Abu Mishaal Secondary Girls School	Ramallah	Females	-	329.00	329.00	1,166.00	3,532.00	64.00	7,165.60	6.15
88	Jalgilia Mixed Elementary School	Ramallah	Mixed	49.00	60.00	109.00	820.00	4,419.00	30.00	7,269.20	8.86
89	shabtin Secondary mixed School	Ramallah	Mixed	168.00	156.00	324.00	1,520.00	2,673.00	17.00	6,301.20	4.15
90	Abu Obeida Elementary Girls School ***	Ramallah	Females	-	586.00	586.00	900.00	800.00	100.00	33,242.60	36.94
91	Kubar Elementary Boys School	Ramallah	Males	186.00	-	186.00	1,440.00	511.00	-	9,789.20	6.80
92	Deir-Greer Secondary Boys school	Ramallah	Males	212.00	-	212.00	1,235.00	2,143.00	180.00	5,363.60	4.34
93	Ain-munjed Elementary School for Boys***	Ramallah	Males	527.00	-	527.00	2,064.00	1,000.00	50.00	40,313.40	19.53
94	Qarawah Secondary Girls School***	Ramallah	Females	-	253.00	253.00	2,822.00	920.00	60.00	24,233.00	8.59
95	Kharbatha Bani Harith Secondary Girls School	Ramallah	Females	-	276.00	276.00	1,000.00	50.00	30.00	10,286.00	10.29

	School Name	Region	Gender	Number of Males	Number of Females	Total Number of Students	School Building Area(m^2)	Yards and Playgrounds Area(m^2)	Shaded Places Area(m^2)	Average Annual Electricity Consumption (kWh/year)	Building Energy Index per Meter Square (kWh/m²/year)
96	Kubar Secondary Girls School	Ramallah	Females	-	113.00	113.00	386.00	2,635.00	-	3,932.40	10.19
97	Almazraa Alqablia Mixed Elementary School	Ramallah	Mixed	84.00	178.00	262.00	500.00	310.00	-	11,011.60	22.02
98	Abu Falah Secondary School for Boys	Ramallah	Males	263.00	-	263.00	15,130.00	8,403.00	20.00	6,174.60	0.41
99	alfajr aljadid Mixed Elementary School	Ramallah	Mixed	126.00	282.00	408.00	1,000.00	553.00	110.00	14,935.80	14.94
100	Shuqba Mixed Elementary School*	Ramallah	Mixed	319.00	282.00	601.00	2,518.00	288.00	83.50	14,672.00	5.83
101	Majida and Seela Girls secondary School	Ramallah	Females	-	282.00	282.00	2,000.00	620.00	60.00	4,206.40	2.10
102	Deir Ammar Secondary Girls School	Ramallah	Females	-	321.00	321.00	1,200.00	1,384.00	-	10,610.60	8.84
103	Singel High Elementary Males School*	Ramallah	Males	434.00	-	434.00	1,332.00	9,304.00	30.00	13,769.00	10.34
104	Al-Janiah Mixed secondary School	Ramallah	Mixed	60.00	119.00	179.00	4,600.00	594.00	46.00	5,830.40	1.27
105	Kfar Naama Secondary Mixed School	Ramallah	Mixed	528.00	41.00	569.00	2,645.00	252.00	-	12,805.00	4.84
106	Aziz Shaheen Secondary Girls School**	Ramallah	Females	-	292.00	292.00	4,885.00	692.00	75.00	23,191.80	-

	School Name	Region	Gender	Number of Males	Number of Females	Total Number of Students	School Building Area(m^2)	Yards and Playgrounds Area(m^2)	Shaded Places Area(m^2)	Average Annual Electricity Consumption (kWh/year)	Building Energy Index per Meter Square (kWh/m²/year)
107	Spanish Elementary Mixed School**	Ramallah	Mixed	141.00	597.00	738.00	2,415.00	2,113.00	-	32,229.20	-
108	Al-labban Algharbi Secondary Males School**	Ramallah	Males	196.00	-	196.00	1,366.00	1,656.00	105.00	10,173.00	-
109	Rantis Secondary Girls School**	Ramallah	Females	-	334.00	334.00	1,077.00	983.00	30.00	7,189.60	-
110	Turmus'ayya Secondary School**	Ramallah	Males	236.00	-	236.00	3,450.00	9,295.00	250.00	15,453.80	-
111	Abu Qash Elementary School for Boys**	Ramallah	Males	182.00	-	182.00	1,230.00	600.00	115.00	7,005.60	-
112	Almughir Secondary Boys School**	Ramallah	Males	427.00	-	427.00	1,650.00	350.00	60.00	8,534.80	-
113	Abu Shkhaidem Girls Secondary School**	Ramallah	Females	-	278.00	278.00	1,000.00	3,908.00	12.00	10,405.80	-
114	Kharbatha Bani Harith Elementary Mixed School**	Ramallah	Mixed	180.00	167.00	347.00	500.00	371.00	116.00	10,286.00	-

* Schools that were having electricity consumption data for less than 5 years.

** Excluded schools that are provided with PV-systems.

*** Electricity consumption outliers without excluding them from the analysis.

4.3 Case Study Data (The Green School)

As mentioned earlier in section 1.3, Chapter 1, the main objective of the research is to quantify the life cycle cost saving associated with reduced energy consumption in Aqqaba green school compared to conventional (non-green) schools in Palestine.

In order to achieve this objective, data pertaining to Aqqaba green school was required and therefore collected. According to the Electrical Department in Municipality of Tubas city, Aqqaba green school is supplied with a photovoltaic (PV) system. The PV-system in Aqqaba green school is a grid-connected system that is connected to the main grid with a capacity of 15 kWp. Technically, the whole generated energy by Aqqaba green school PV-system is exported to the grid that is operated by the utility service provider, while Aqqaba green school is totally supplied with its total energy demand from the utility service provider.

At the end of each month, an officer from the utility service provider records the energy consumption meter and energy generation meter readings from Aqqaba green school, then the total energy consumed readings are subtracted from the total net generated energy at the end of each year. If there is a surplus of energy, then the utility service provider credits 75% of it to the green school's account with an electricity tariff of 0.692 ILS/kWh. The data of both energy consumption meter and net energy generation meter of the PV-system were obtained from the Electrical Department in the Municipality of Tubas city. See Appendix A for the raw data of both energy consumption meter and net energy generation meter of the PV-system of Aqqaba green school as received from the Municipality of Tubas city.

Aqqaba green school was established in 2016 and the construction of the two-floor green school building was completed in May 2016. The monthly energy consumption collected data for Aqqaba green school which covers the two years readings of March 2017 to February 2019, were used in this research. Table 4.6 below represents Aqqaba school monthly energy readings exported to the grid versus the energy consumption from the electricity bills for a period of two years.

Table 4.6: The monthly total energy readings exported to the grid from Aqqaba school versus its energy consumption according to electricity bills.

Reading date	Energy consumption according to electricity bills (kWh)	Total energy exported to the grid (kWh)
28/3/2017	703.00	1,062.00
29/5/2017*	858.00	1,511.00
1/7/2017	560.00	1,188.00
31/7/2017	786.00	2,239.00
27/8/2017	709.00	1,590.00
27/9/2017	1,766.00	723.00
29/10/2017	1,249.00	944.00
28/12/2017*	1,717.00	1,370.00
28/1/2018	380.00	693.00
28/2/2018	824.00	534.00
28/3/2018	724.00	565.00
2/5/2018	612.00	1,785.00
31/5/2018	398.00	1,528.00

Table 4.6: (continued)

Reading date	Energy consumption according to electricity bills (kWh)	Total energy exported to the grid (kWh)
8/7/2018	504.00	4,573.00
4/9/2018*	721.00	926.00
27/9/2018	1,365.00	518.00
27/10/2018	1,548.00	521.00
30/11/2018	0.00	0.00
30/12/2018	0.00	0.00
31/1/2019	1,740.00	1,669.00
28/2/2019	627.00	566.00
Total	17,791.00	24,505.00
Average	8,895.50	12,252.50

The reading date with * covers two months period.

The data of Aqqaba green school area and number of students were obtained from the Statistics and Planning Department in the Palestinian Ministry of Education in Ramallah city. Table 4.7 below represents Aqqaba green school area and number of students.

Table 4.7: Aqqaba green school areas and number of students.

School name	Region	Gender	Total number of students	School building area (m^2)	Average annual electricity consumption (kWh)
Aqqaba green school	Tubas	Females	151.00	1,408.00	8,895.50

4.4 Life Cycle Cost Components Data

While conducting the analysis for this research, the international standard ISO 15686-5:2008 was used as a reference for identifying the life cycle cost elements needed for obtaining the energy life cycle cost of public schools in Palestine. These were: Inflation rate, Buildings service life, and the period of analysis.

4.4.1 Energy Price Inflation in Palestine

Inflation rate reflects the increment in the general price level of goods and services (ISO15686-5, 2008). According to Statistics Canada (2012), inflation rates can be obtained from frequently issued periodic reports, by Central Bureau of Statistics, that contain data about the consumer price index (CPI) for different types of goods and services prepared by department of statistics. According to Mirzadeh and Birgisson (2015), the energy price inflation should be addressed separately from general price inflation when performing life cycle cost analysis as mentioned in Chapter two, section 2.3.2.

For Palestine, there are no officially published forecasts for energy price inflation, therefore the historical records of the annual change in electricity prices in Palestine, which are available at the electricity service provider companies for years 2011 to 2018, were used to forecast the electricity inflation rate in Palestine. Notably, the annual change in electricity price data in Palestine were cover a relatively short period of time ranged from years (2011 to 2018).

It is worth mentioning that the Palestinian Electricity Regulatory Council was established in 2011, and it started to oblige the electricity service provider companies to start recording the changes in electricity prices in 2011.

The prices of electricity in Jerusalem District Electricity company and Northern Electricity Distribution company were different as can be seen in Table 4.8 below. Therefore, the inflation rate for electricity cost is estimated for each company separately as discussed in details in Chapter five, section 5.2.3. The reason for estimating the inflation rate for each service provider separately that the future inflation rates are estimated based on the historical energy price.

Table 4.8: Historical records of the annual electricity prices in Palestine.

Jerusalem District Electricity company		**Northern Electricity Distribution company**	
Year	**Electricity price (ILS/kWh)**	**Year**	**Electricity price (ILS/kWh)**
2011	0.5876	2011	_
2012	0.6493	2012	0.6693
2013	0.667	2013	0.7215
2014	0.685	2014	0.7215
2015	0.685	2015	0.6206
2016	0.685	2016	0.5916
2017	0.6251	2017	0.6186
2018	0.631	2018	0.6215

4.4.2 Buildings Service Life

For determining the service life of buildings in this research, The International standard ISO 15686-5:2008 mandates that the building estimated service life should be at least as long as the design life. Kelly (2007) argues that the design life of concrete structures is expected to extend at least for 60 years.

Therefore, based on the design life of concrete structures, a period of 60 years was chosen as a service life for developing an energy life cycle cost baseline for conventional schools in Palestine.

4.4.3 Period of Analysis

For determining the time horizon of the analysis, ISO 15686-5 (2008) suggests that the period of analysis may cover the whole life cycle of the assets. But it is recommended not to extend the analysis period over 100 years, as the results may become insignificant beyond this period. Accordingly, Heralova (2017) suggests that the analysis period for buildings usually ranges from 25 to 30 years for public sectors because the present value of future costs may be insignificant beyond this period. On the contrary, Swarr et al.(2011) suggested that a life cycle cost analysis should include the whole life cycle of a building, which is determined by its service life. Therefore, since the purpose of this research is to develop an energy life cycle budget for public schools in Palestine, the analysis conducted over a period of 60 years, in order to cover the whole building life cycle, starting from 2019 to 2079.

4.5 Chapter Summery

This chapter discussed all types of the collected data during this research, how each type of data was gathered, and used. In addition, it explains how the population and sample size for this research were specified and selected. A specific data about the needed life cycle components were discussed and determined at the end of this chapter.

In the next chapter (Chapter five), detailed steps of how the collected data were employed to establish the needed baseline are discussed. Also, the results of the analysis are presented and discussed.

Chapter Five
Data Analysis and Discussion

This chapter discusses the analysis and the results of the collected data presented the previous chapter (Chapter four). The first section of this chapter outlined how the data was processed, sorted, and arranged in order to calculate the average annual energy costs for public schools in West Bank/Palestine. The subsequent sections explain the detailed analysis and calculations of how the energy life cycle cost baselines for public schools in West Bank/Palestine and for Aqqaba school were established. The chapter ends with an evaluation of the actual energy efficiency and performance of Aqqaba green school compared to the other public schools in West Bank/Palestine.

5.1 Energy Consumption Data Analysis

For the purpose of establishing the needed energy life cycle baseline for public schools in West Bank/Palestine, the monthly energy consumption data for the public schools' sample was obtained from the electricity utility service providers as mentioned earlier in Chapter four section 4.2. The sample monthly energy consumption data were tabulated in excel sheets and converted to annual consumptions in order to reduce the variation in the monthly data.

After excluding the schools that are provided with PV-systems from the research sample, due to the unavailability of their PV-systems types and their energy consumption data details, the energy consumption potential outliers for the sample of 103 schools were identified using the Interquartile intervals by applying the Five Number Analysis (Min, Q1, Q2, Q3, Max) (Weiss, 2011) as follow:

1. After organizing the data of the selected 103 schools in ascending order depending on their electricity consumption, the median value of the selected schools was calculated using Equation 5.1 (Weiss, 2011):

$$Median = \frac{n+1}{2} \quad (5.\ 1)$$

Where:

(n) = represents the sample size (103 schools).

The median value of the annual electricity consumption was 10,060.40 kWh/year since it corresponds to the number of schools median of 52 using Equation 5.1.

2. Since the median split the data in into two halves, the median value for the entire data represents the second quartile (Q2), while the median of the data that lies below the median of the entire data represents the first quartile (Q1). And the median of the data that lies above the median of the entire data represents the third quartile (Q3). As a result, the value of Q1=5,672.60 kWh/year, Q2=10,060.40 kWh/year and Q3= 12,519.60 kWh/year.

3. In order to identify the outliers, the Interquartile Interval was calculated using Equations 5.2 and 5.3 (Weiss, 2011):

$$Lower\ boundary = Q1 - 1.5\ IQR \tag{5. 2}$$

$$Upper\ boundary = Q3 + 1.5\ IQR \tag{5. 3}$$

Where:

(Q1) = the first quartile which is the median of the data that lies below the median of the entire data.

(Q3) = the third quartile which is the median of the data that lies above the median of the entire data.

(IQR) = the Interquartile range and is calculated by subtracting Q3 from Q1.

As a result, the value of IQR was 6,847.00 kWh/year, the value of the Interquartile interval Lower boundary was -4,597.90 kWh/year, and the value of the Upper boundary was 22,790.10 kWh/year.

4. The outliers of annual energy consumption were identified as the values that fall outside the Interquartile interval boundaries. In this research four schools fall outside the Interquartile interval. In Table 4.5 the schools marked with triple asterisks (***) represent the outliers.

It is worth mentioning that the outliers in this research were identified but were included in the calculations of mean as the energy consumption data in this research are real and not observed values. Table 5.1 below summarizes the Five Number Analysis summery for the annual energy consumption data.

Table 5.1: Summary of the Five Number Analysis for the annual energy consumption data without excluding the outliers (kWh/year).

Min	Q1	Q2	Q3	Max	IQR	Lower boundary	Upper boundary
2,597.80	5,672.60	10,060.40	12,519.60	40,344.40	6,847.00	-4,597.90	22,790.10

Moreover, for providing an indication regarding the annual electricity consumption data for public schools in the sample, the frequency histogram and boxplot are plotted as shown in Figures 5.1 and 5.2 below.

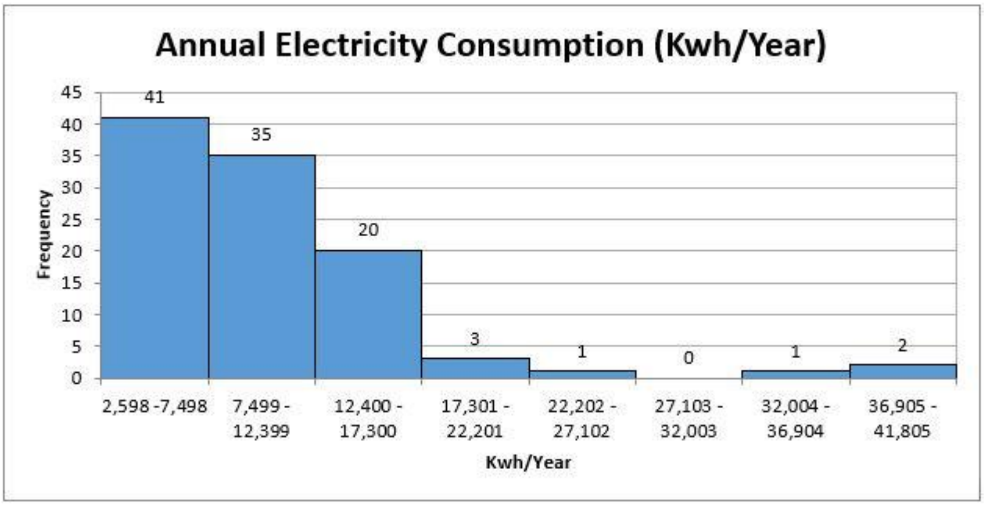

Figure 5.1: The annual energy consumption data histogram for the selected public schools' sample.

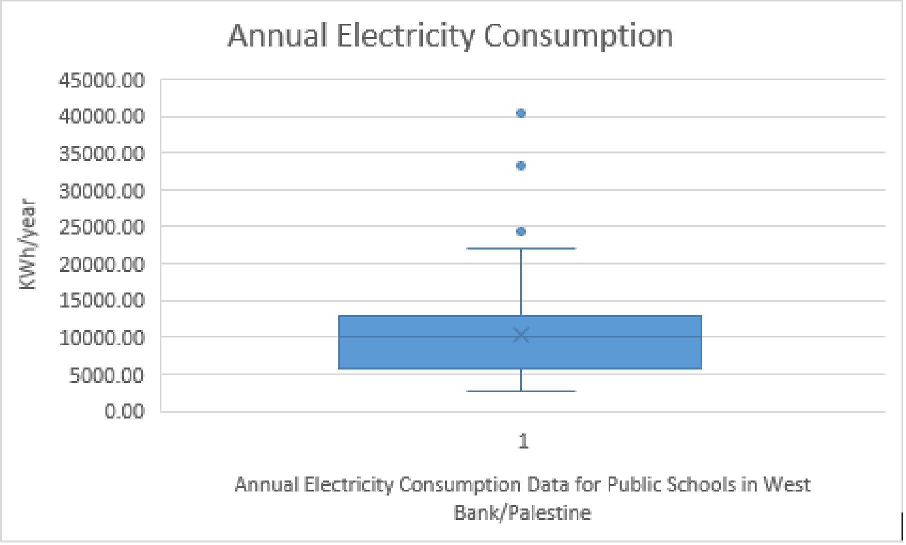

Figure 5.2: The annual energy consumption data Boxplot for the selected public schools' sample.

Figure 5.1 suggests that the annual energy consumption data is skewed to the left, while Figure 5.2, and shows the potential outliers of the annual energy consumption data.

After identifying the outliers, the arithmetic mean of the annual electricity consumption for the sample (without excluding the outliers) was calculated by dividing the sum of the average annual electricity consumption for the sample over the sample size. The arithmetic mean of the public schools' sample is 10,367.63 kWh/year, this corresponds to a building energy index (BEI) of 8.34 kWh/m^2/year as indicated in section 5.6. According to Denny and Mallery (2014), the BEI is identified as a performance indicator for measuring the total annual end-use energy consumption in a building.

The arithmetic mean of the annual electricity consumption of the sample (excluding the outliers) is 9,391.23 kWh/year. The arithmetic mean of the public schools' sample differs from the arithmetic mean of the sample when excluding the outliers by 976.40 kwh/year. Figure 5.3 below represents the variation of the annual electricity consumption data for the research sample.

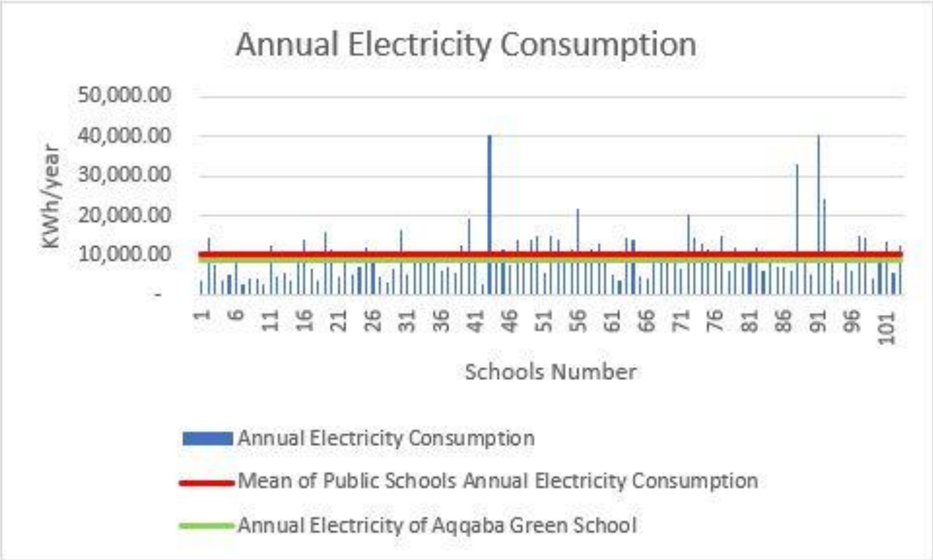

Figure 5.3: The variation of annual energy consumption data for the selected public schools sample.

According to Figure 5.3, the maximum value of the annual energy consumption was 40,344.40 kWh/year, while the minimum value was 2,597.80 kWh/year.

For the purpose of calculating the cost of the annual energy consumptions, the annual energy consumption for each school was multiplied by the electricity price tariff used by its corresponding electricity service provider. It is worth mentioning that Jerusalem District Electricity company listed Ramallah public schools under the commercial facilities category with an electricity price tariff of 0.6310 ILS/kWh for the year 2018. While

Northern Electricity Distribution Company listed Nablus and Jenin public schools under the pre-payment household facilities category with an electricity price tariff of 0.6215 ILS/kWh for the same year. Therefore, the annual average energy cost for public schools in this research depending on both Jerusalem District Electricity company and Northern Electricity Distribution company was 6,484.06 ILS/year.

To obtain an average energy price tariff for public schools that can be used in the analysis, the mean of the annual energy cost (6,484.06 ILS/year) was divided by the mean of the annual electricity consumption (10,367.63 kWh/year). As a result, the average energy price tariff for public schools in Palestine is 0.6254 ILS/kWh, this average price was used in determining the baseline of the annual energy costs and therefore in the life cycle assessment. The following section (section 5.2) provides the elements and calculations that are needed in order to establish the energy life cycle cost baseline for public schools in West Bank/Palestine.

5.2 Energy Life Cycle Cost Baseline for Public Schools in West Bank/Palestine

To establish the energy life cycle cost baseline for public schools in West Bank/Palestine, the International Standard ISO 15686-5:2008 is used as a reference for identifying the life cycle cost elements. The elements needed for establishing the energy life cycle cost baseline are: building service life, period of analysis, energy inflation rate, and discount /interest rate.

5.2.1 Building Service Life

The building estimated service life should be at least as long as the design life according to the International standard ISO 15686-5:2008. And since the design life of concrete structures is expected to extend to least 60 years as mentioned in Chapter four, a period of 60 years was used as a service life for developing an energy life cycle cost baseline for public schools in West Bank/Palestine.

5.2.2 Period of Analysis

According to the international standard ISO 15686-5:2008, the period of analysis may cover the whole life cycle of an asset, which is determined by its service life. Therefore, since the purpose of this research is to develop an energy life cycle cost baseline for public schools in West Bank/Palestine, the analysis covers a period of 60 years starting from 2019, as the base year, to 2079 in order to cover the whole building life cycle as determined by the design life of concrete structures.

5.2.3 Energy Inflation Rate

Due to the unavailability of an officially published forecasts for energy prices inflations in Palestine, the historical records of the annual change in electricity prices that are available for the period 2011 to 2018 in Palestine were used to calculate the electricity inflation rate in Palestine.

It must be mentioned that the prices of electricity in Jerusalem District Electricity Company and Northern Electricity Distribution Company are different and therefore the two companies were treated separately. The inflation rate for electricity cost was calculated for each company by:

1. Subtracting the original electricity price (B) from the current electricity price (A) and then dividing the result by the original electricity price (B): ((A-B)/B).

2. Multiplying the result from previous step by100%.

3. Calculating the average inflation rate for the both companies to be used in the LCC calculations. Table 5.2 below illustrates the inflation rate calculations for both companies.

Table 5.2: Electricity inflation rate in Palestine.

Jerusalem District Electricity company			**Northern Electricity Distribution company**		
Year	**Electricity price (ILS/kWh)**	**Inflation rate (%)**	**Year**	**Electricity price (ILS/kWh)**	**Inflation rate (%)**
2011	0.5876		2011	_	
2012	0.6493	10.50	2012	0.6693	
2013	0.667	2.73	2013	0.7215	7.80
2014	0.685	2.70	2014	0.7215	0.00
2015	0.685	0.00	2015	0.6206	-13.98
2016	0.685	0.00	2016	0.5916	-4.67
2017	0.6251	-8.74	2017	0.6186	4.56
2018	0.631	0.94	2018	0.6215	0.47
	Sum	8.12		**Sum**	-5.83
	Average	1.16		**Average**	-0.97
General electricity inflation rate in Palestine			0.095%		

From Table 5.2, it can be noticed that energy prices of Jerusalem District Electricity company had average inflation rate of 1.16% annually. While energy prices of Northern Electricity Distribution company exhibited a deflation rate of -0.97% annually (which is unlikely to happen based on the historical trend of energy prices worldwide).

According to Table 5.2, the overall average annual increase of electricity prices in Palestine was around 0.095%. This value of inflation is very low in comparison to the energy price inflation trend world-wide, which averaged about 2.62% (The World Bank, 2019). It is worth mentioning that this global rate is related to the energy prices, and not specifically for electricity price, which is not available as a stand-alone item in the World Bank data. Nevertheless, this shows that the energy price in the world is generally increasing.

The reason of the low value of the calculated inflation rate in this section might be attributed to the short period of time that the data covers. It is expected to obtain a different inflation rate if the analysis is carried out based on longer time series data. However, such data are not available with the relevant authorities as they stated.

Accordingly, and to make the analysis more meaningful, particularly since there are no officially published forecasts for energy prices in Palestine, the energy life cycle cost was estimated using different scenarios for energy price inflation rates. The energy price inflation considered scenarios range from 0% to 7% with an increment of (1-2) %.

The purpose of using 0% is to quantify the energy saving in real terms. Based on the historical trend of the energy price inflation the highest inflation rate recorded is 12.47 (The World Bank, 2019), while an inflation rate of 7% (which is used as an upper limit in this research) is not supported according to the World Bank records.

It is believed that an inflation rate of 2% is considered as a probable scenario for energy inflation around the world. Therefore, and to ensure covering the probable energy inflation scenarios the analysis to be presented shortly looked at inflation rates of 0%, 2%, 3%, 5%, and 7%. In addition, -1% and -2% inflation rate scenarios were evaluated in order to assess the effect of an energy price deflation on the outcome of the analysis.

5.2.4 Discount /Interest Rate

Discount rate is used to find the equivalent present value of a future amount of money. The average interest rate for governmental loans in Palestine is around 5%. Therefore, in this research 5% discount rate was used in estimating the present value of energy life cycle cost for Palestinian conventional schools.

According to Dwaikat and Ali (2018a), when comparing different investment alternatives, it is essential to determine a discount rate in conducting a life cycle cost analysis, in order to find the equivalent value for each alternative in a common base date. Accordingly, for discounting costs to present values Equation 2.1 that was mentioned in Chapter two is used (Reidy et al., 2005):

$$PV = \frac{F_Y}{(1+DISC)^Y} \tag{2.1}$$

Where:

(PV) = the present value in year 0

(F_Y) = Future value in year Y

(DISC) = the discount rate.

(Y) = the number of years in the future.

In estimating the energy life cycle cost for public schools in this research, 2019 was used as the base year for the calculations. All costs data are available in the most used currency in Palestine, which is the Israeli shekel (ILS). Moreover, the total energy life cycle cost was projected over the whole life cycle of schools, starting from 2019 up to 2079 using Equation 3.3 that was mentioned in Chapter 3.

It is worth mentioning that some schools in the sample have been in operation for more than 30 years. Nevertheless, it is assumed that the buildings will remain in use for an additional 60 years. This is likely to happen in Palestine, because we have currently schools under operation for more than 100 years.

The energy life cycle cost analysis was obtained by identifying, estimating, and projecting the life cycle cost of energy components over the defined period of 60 years. Then the estimated annual energy inflated cost was tabulated and the annual sums were obtained in order to determine the total energy life cycle budget as shown in Table 5.3 below.

Table 5.3: Total estimated energy LCC for public schools in West Bank/Palestine with 2% energy inflation rate.

Total energy life cycle budget for public schools in West Bank/ Palestine (ILS), with 2% energy inflation rate						
Year	2019	2020	2021	2022	2023	2024
Inflated Annual energy cost	6,531.61	6,662.24	6,795.49	6,931.40	7,070.02	7,211.43
Cumulative energy cost	6,531.61	13,193.85	19,989.34	26,920.74	33,990.76	41,202.19
Year	2025	2026	2027	2028	2029	2030
Inflated Annual energy cost	7,355.65	7,502.77	7,652.82	7,805.88	7,962.00	8,121.24
Cumulative energy cost	48,557.84	56,060.61	63,713.43	71,519.31	79,481.30	87,602.54
Year	2031	2032	2033	2034	2035	2036
Inflated Annual energy cost	8,283.66	8,449.33	8,618.32	8,790.69	8,966.50	9,145.83
Cumulative energy cost	95,886.20	104,335.53	112,953.85	121,744.54	130,711.04	139,856.87
Year	2037	2038	2039	2040	2041	2042
Inflated Annual energy cost	9,328.75	9,515.32	9,705.63	9,899.74	10,097.74	10,299.69
Cumulative energy cost	149,185.62	158,700.94	168,406.57	178,306.31	188,404.05	198,703.74
Year	2043	2044	2045	2046	2047	2048
Inflated Annual energy cost	10,505.68	10,715.80	10,930.11	11,148.72	11,371.69	11,599.12
Cumulative energy cost	209,209.43	219,925.22	230,855.34	242,004.06	253,375.75	264,974.87
Year	2049	2050	2051	2052	2053	2054
Inflated Annual energy cost	11,831.11	12,067.73	12,309.08	12,555.27	12,806.37	13,062.50
Cumulative energy cost	276,805.98	288,873.71	301,182.79	313,738.06	326,544.43	339,606.93
Year	2055	2056	2057	2058	2059	2060
Inflated Annual energy cost	13,323.75	13,590.22	13,862.03	14,139.27	14,422.05	14,710.50
Cumulative energy cost	352,930.68	366,520.90	380,382.93	394,522.20	408,944.25	423,654.75
Year	2061	2062	2063	2064	2065	2066
Inflated Annual energy cost	15,004.70	15,304.80	15,610.90	15,923.11	16,241.58	16,566.41
Cumulative energy cost	438,659.45	453,964.25	469,575.15	485,498.26	501,739.83	518,306.24
Year	2067	2068	2069	2070	2071	2072

Inflated Annual energy cost	16,897.73	17,235.69	17,580.40	17,932.01	18,290.65	18,656.46
Cumulative energy cost	535,203.97	552,439.66	570,020.07	587,952.08	606,242.73	624,899.20
Year	2073	2074	2075	2076	2077	2078
Inflated Annual energy cost	19,029.59	19,410.19	19,798.39	20,194.36	20,598.24	21,010.21
Cumulative energy cost	643,928.79	663,338.97	683,137.36	703,331.72	723,929.97	744,940.18
Year	2079	-	-	-	-	-
Inflated Annual energy cost	21,430.41	-	-	-	-	-
Cumulative energy cost	766,370.59	-	-	-	-	-

*Period of analysis (Year):60

*Buildings average annual energy consumption (kWh/Year): 10,367.63

*Average energy price tariff (ILS/kWh): 0.63

*Current annual energy cost (ILS/Year): 6,531.61

The previous analysis as summarized in Table 5.3 represents the energy life cycle cost baseline for public schools in West Bank/Palestine. The total estimated energy life cycle budget for public schools in West Bank/Palestine in the nominal terms equals 766,370.59 ILS, which covers a period of 60 years. It represents an equivalent present value of 121,214.45 ILS. The equivalent present value of the total estimated energy life cycle cost was calculated by discounting all the estimated energy life cycle costs in the nominal terms to the base year 2019.

It must be mentioned that, the energy life cycle budget includes all the energy life cycle cost elements along the whole building life cycle, and that the energy life cycle cost baseline represents a time phased energy life cycle budget.

The cumulative energy life cycle cost baseline in Table 5.3 is graphically shown in Figure 5.4 below.

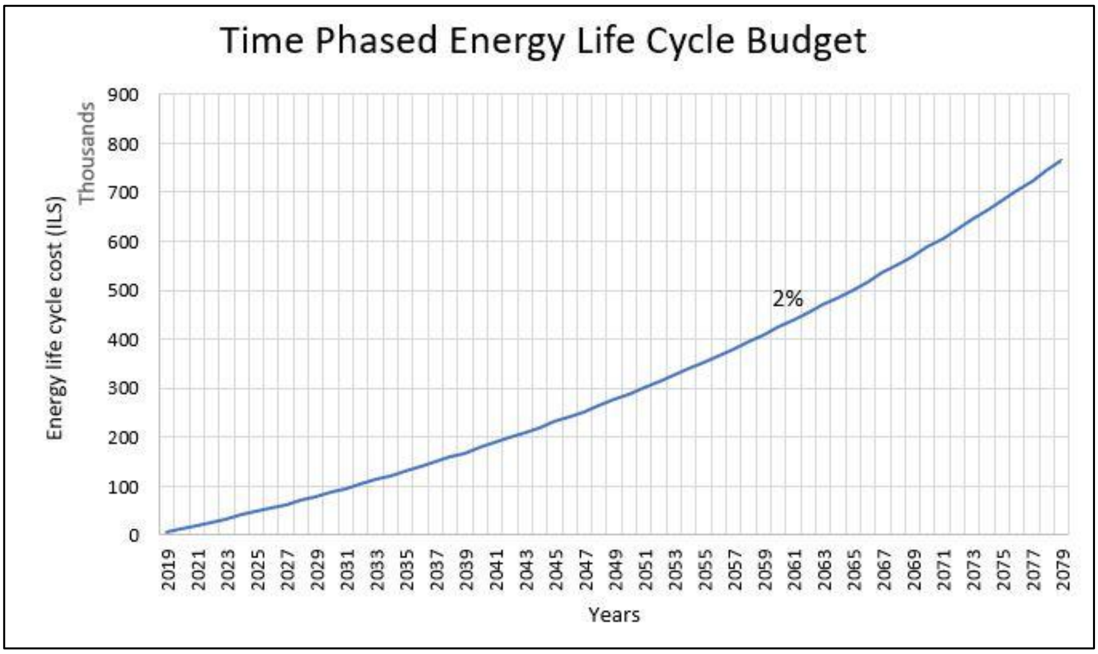

Figure 5.4: Energy life cycle cost baseline for public schools in Palestine at 2% inflation rate.

It can be noticed from Figure 5.4 that the energy life cycle cost curve is affected exponentially by the energy price inflation.

The energy life cycle cost analysis has been repeated using different inflation scenarios as discussed earlier in section 5.2.3, and the results tabulated in Table 5.4. See Appendix B for the full calculations of all inflation scenarios that were used in estimating the energy life cycle cost for public schools in West Bank/Palestine.

Table 5.4: Estimated energy life cycle cost for public schools in West Bank/Palestine considering different energy inflation scenarios.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Interest rate (%)	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Energy price inflation rate (%)	-2.00%	-1.00%	0.00%	2.00%	3.00%	5.00%	7.00%
Period of analysis (Year)	60.00	60.00	60.00	60.00	60.00	60.00	60.00
Buildings average annual energy consumption (kWh/Year)	10,367.63	10,367.63	10,367.63	10,367.63	10,367.63	10,367.63	10,367.63
Average energy price tariff (ILS/kWh)	0.6254	0.6254	0.6254	0.6254	0.6254	0.6254	0.6254
Inflation adjusted i (nominal discount rate)	2.90%	3.95%	5.00%	7.10%	8.15%	10.25%	12.35%
Constant annual energy cost (ILS/Year)	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61
Life cycle energy budget (ILS)	231,348.95	299,353.43	398,428.21	766,370.59	1,103,483.11	2,431,476.10	5,692,081.33
NPV(ILS)	126,161.98	124,887.61	123,638.74	121,214.45	120,037.61	117,751.18	115,550.22

Table 5.4 shows the energy life cycle cost throughout the whole building life cycle at different energy inflation rates. In real terms, the energy life cycle cost throughout the whole building life cycle is about 398,428.21 ILS which equals to 123,638.74 ILS in the present terms when the inflation rate is zero. These costs increase to 766,370.59 ILS at 2% average annual energy price increase, which is equal to 121,214.45 ILS as present value. The costs reach to 5,692,081.33 ILS at 7% average annual increase of energy prices, corresponding to 115,550.22 ILS as the present value.

On the other hand, when decreasing the average annual energy price to -2%, the energy life cycle cost throughout the whole building life cycle decreases to be around 231,348.95 ILS, which equals 126,161.98 ILS as present value.

The energy life cycle calculations in Table 5.4 are presented graphically as shown in Figure 5.5.

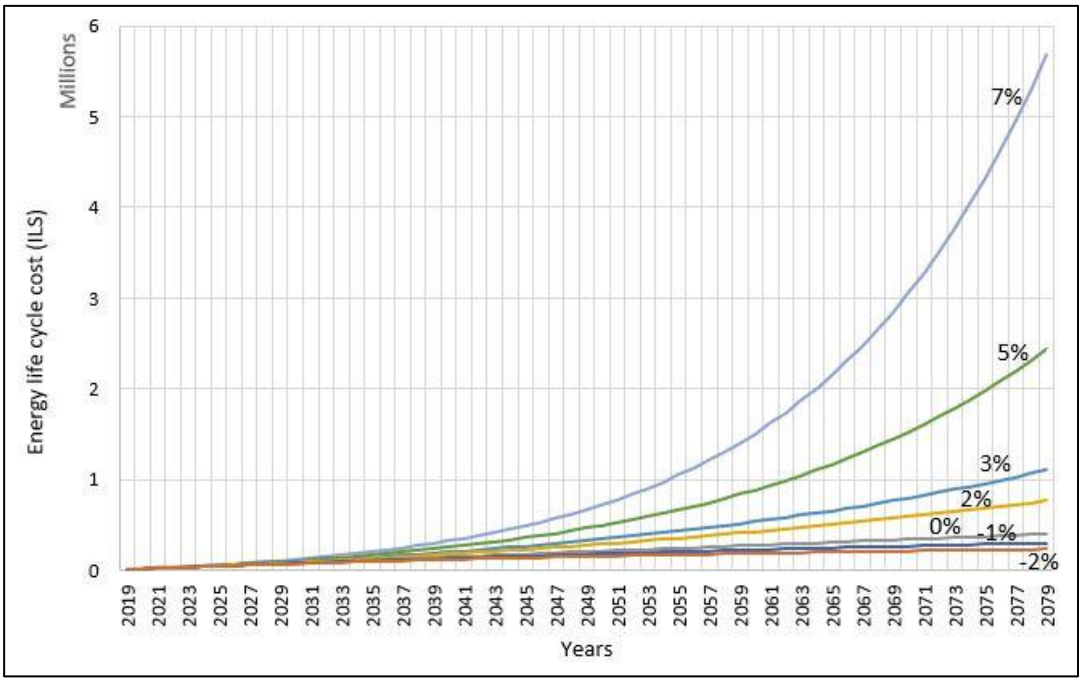

Figure 5.5: Energy life cycle cost baseline for public schools in Palestine using different inflation scenarios.

From Figure 5.5, it can be observed that when the energy inflation rate increases its exponential effect becomes more significant on the energy life cycle cost.

5.3 Energy Life Cycle Cost Baseline for Aqqaba Green School in West Bank/Palestine

Aligned with the main objective of this research, which is to conduct an estimation of the life cycle cost of energy in public schools in West Bank/ Palestine, this research was also conducted in order to quantify the life cycle cost saving associated with reduced energy consumption in Aqqaba green school. For this purpose, the monthly energy consumption data for

Aqqaba green school was collected from Tubas Municipality as mentioned earlier in Chapter 4 section 4.3.

It is worth mentioning that Aqqaba green school is supplied with a grid-connected photovoltaic (PV) system that is connected to the main grid. This means that the utility service provider supplies Aqqaba green school with its total energy demand, while the whole generated energy by Aqqaba green school PV-system is exported to the main grid.

According to the Electrical Department in the Municipality of Tubas city, at the end of each month an officer from the utility service provider records the energy consumption meter and the energy generation meter readings from Aqqaba green school. The total energy consumed readings are then subtracted from the total net generated energy at the end of each year. If there is a surplus of energy, then the utility services provider credits 75% of the surplus to the green school's account.

It is worth reminding that the construction of the two floors of Aqqaba green school building was completed in May 2016. Therefore, the monthly energy consumption collected data for Aqqaba green school that were used in this research covers two years readings starting from March 2017 to February 2019.

In order to estimate the economic benefits gained from the provided PV-system in Aqqaba green school for the two years of operation, Equation 5.4 was applied*:*

$$A = (B - C) * 0.75D \tag{5. 4}$$

Where:

(A) = Aqqaba green school economic benefits from the PV-system.

(B) = Total net energy generated by the PV-system in Aqqaba green school.

(C) = Total energy consumption according to electricity bills for Aqqaba green school.

(D) = The electricity price tariff in Tubas city which is equal to 0.6920 (ILS/kWh).

Therefore, Aqqaba green school economic benefits from the PV-system for the two years period was calculated using Equation 5.4 as follow:

(24,505 kWh/year – 17,791 kWh/year) x 0.75 x 0.6920 ILS/kWh = 4,844.151 ILS per two years.

Based on the previous calculations, Aqqaba green school annual savings that gained from the provided PV-system can be calculated by taking the average of the two years savings (4,844.151ILS per two years /2) which yields savings of 2,422.07 ILS per year.

It is worth mentioning that in a previous master degree research conducted by Hodiri (2018) in order to evaluate the actual performance of Aqqaba green school, Hodiri (2018) reported that Aqqaba green school saving realized from the provided PV-system in the first year of operation was 2,297 ILS. It can be said that Aqqaba green school PV-system savings that resulted from Hodiri (2018) research were very close to the savings value that was calculated in this research (2,422.07 ILS per year). This slight difference in results is most probably attributed to the time horizon of data used, since Hodiri (2018) used monthly energy consumption data that covers one year readings, while the researcher of this research used data that covers two years readings.

From a life cycle perspective, using 60 years period of analysis from 2019 to 2079 and an inflations scenario of 2%, savings from Aqqaba green school PV-system were found to be 284,187.70 ILS, which represents an equivalent present value of 44,949.08 ILS.

Table 5.5 below represents Aqqaba green school monthly energy readings exported to the grid versus the energy consumption from the electricity bills.

Table 5.5: Aqqaba green school monthly energy readings exported to the grid versus its energy consumption from the electricity bills.

Reading date	Energy consumption according to electricity bills (kWh)	Total energy exported to the grid (kWh)	Difference between the energy exported to the grid and the consumed energy (kWh)
28/3/2017	703.00	1,062.00	-359.00
29/5/2017*	858.00	1,511.00	-653.00
1/7/2017	560.00	1,188.00	-628.00

Table 5.5: (continued)

Reading date	Energy consumption according to electricity bills (kWh)	Total energy exported to the grid (kWh)	Difference between the energy exported to the grid and the consumed energy (kWh)
31/7/2017	786.00	2,239.00	-1,453.00
27/8/2017	709.00	1,590.00	-881.00
27/9/2017	1,766.00	723.00	1,043.00
29/10/2017	1,249.00	944.00	305.00
28/12/2017*	1,717.00	1,370.00	347.00
28/1/2018	380.00	693.00	-313.00
28/2/2018	824.00	534.00	290.00
28/3/2018	724.00	565.00	159.00
2/5/2018	612.00	1,785.00	-1,173.00
31/5/2018	398.00	1,528.00	-1,130.00
8/7/2018	504.00	4,573.00	-4,069.00
4/9/2018*	721.00	926.00	-205.00
27/9/2018	1,365.00	518.00	847.00
27/10/2018	1,548.00	521.00	1,027.00
30/11/2018	0.00	0.00	0.00
30/12/2018	0.00	0.00	0.00
31/1/2019	1,740.00	1,669.00	71.00
28/2/2019	627.00	566.00	61.00
Total	17,791.00	24,505.00	-6,714.00

The reading date with * covers two months period.

The reading with negative sign means energy savings gained from the PV-system.

The monthly energy consumption data for Aqqaba green school was converted to annual consumption for the purpose of avoiding variation in the monthly data. Then the arithmetic mean of Aqqaba green school annual consumption was calculated and found to be 8,895.50 kWh/year, this corresponds to a building energy index of 6.32 kWh/m^2/year as indicated in section 5.6.

This means that Aqqaba green school consumed less energy than the public (non-green) schools by 2.02 kWh/m²/year, this corresponds to a saving percentage of 24.22%.

Furthermore, the annual energy consumption of Aqqaba green school (8,895.50 kWh/year) was multiplied by Tubas electricity price tariff (0.6920 ILS/kWh) for calculating the cost of the annual energy consumption for Aqqaba green school which is equivalent to (8,895.50 kWh/year * 0.6920ILS/kWh) = 6,155.69 ILS/year.

5.3.1 The Economic Analysis of Aqqaba Green School from Life Cycle Perspective

The energy life cycle cost analysis was performed using different scenarios for energy price inflation in order to quantify the savings associated with reduced energy consumption in Aqqaba green school over its whole life cycle. Aqqaba green school estimated annual energy inflated cost and the accumulated annual sums are given in Table 5.6 below. The calculations were projected over a period of 60 years with 2% as an inflation rate.

Table 5.6: Total estimated energy LCC for Aqqaba green school with 2% energy inflation rate.

Total energy life cycle budget for Aqqaba green school (ILS), with 2% energy inflation rate						
Year	2019	2020	2021	2022	2023	2024
Inflated annual energy cost	6,155.69	6,278.80	6,404.38	6,532.47	6,663.12	6,796.38
Cumulative energy cost	6,155.69	12,434.49	18,838.87	25,371.34	32,034.46	38,830.84
Year	2025	2026	2027	2028	2029	2030
Inflated annual energy cost	6,932.31	7,070.95	7,212.37	7,356.62	7,503.75	7,653.83
Cumulative energy cost	45,763.14	52,834.10	60,046.47	67,403.09	74,906.84	82,560.67
Year	2031	2032	2033	2034	2035	2036
Inflated annual energy cost	7,806.90	7,963.04	8,122.30	8,284.75	8,450.44	8,619.45
Cumulative energy cost	90,367.57	98,330.61	106,452.91	114,737.66	123,188.11	131,807.56
Year	2037	2038	2039	2040	2041	2042
Inflated annual energy cost	8,791.84	8,967.68	9,147.03	9,329.97	9,516.57	9,706.90
Cumulative energy cost	140,599.40	149,567.08	158,714.11	168,044.08	177,560.65	187,267.55
Year	2043	2044	2045	2046	2047	2048
Inflated annual energy cost	9,901.04	10,099.06	10,301.04	10,507.06	10,717.21	10,931.55
Cumulative energy cost	197,168.60	207,267.66	217,568.70	228,075.76	238,792.97	249,724.52
Year	2049	2050	2051	2052	2053	2054
Inflated annual energy cost	11,150.18	11,373.18	11,600.65	11,832.66	12,069.31	12,310.70
Cumulative energy cost	260,874.70	272,247.88	283,848.53	295,681.19	307,750.51	320,061.21
Year	2055	2056	2057	2058	2059	2060
Inflated annual energy cost	12,556.91	12,808.05	13,064.21	13,325.50	13,592.01	13,863.85
Cumulative energy cost	332,618.12	345,426.17	358,490.39	371,815.88	385,407.89	399,271.74
Year	2061	2062	2063	2064	2065	2066
Inflated annual energy cost	14,141.12	14,423.95	14,712.43	15,006.67	15,306.81	15,612.94
Cumulative energy cost	413,412.86	427,836.81	442,549.24	457,555.91	472,862.72	488,475.67
Year	2067	2068	2069	2070	2071	2072

Inflated annual energy cost	15,925.20	16,243.71	16,568.58	16,899.95	17,237.95	17,582.71
Cumulative energy cost	504,400.87	520,644.58	537,213.16	554,113.11	571,351.06	588,933.77
Year	2073	2074	2075	2076	2077	2078
Inflated annual energy cost	17,934.37	18,293.05	18,658.91	19,032.09	19,412.73	19,800.99
Cumulative energy cost	606,868.14	625,161.19	643,820.11	662,852.20	682,264.93	702,065.92
Year	2079	-	-	-	-	-
Inflated annual energy cost	20,197.01	-	-	-	-	-
Cumulative energy cost	722,262.93	-	-	-	-	-

*Period of analysis (Year):60

*Buildings average annual energy consumption (kWh/Year): 8895.50

*Average energy price tariff (ILS/kWh): 0.69

*Constant annual energy cost (ILS/Year): 6155.69

From Table 5.6, the estimated Energy life cycle cost baseline for Aqqaba green school was 722,262.93 ILS in the nominal terms, which represents an equivalent present value of 114,238.08 ILS. The equivalent present value of the total estimated energy life cycle cost was calculated by discounting all the future energy life cycle costs to the base year 2019.

Aqqaba green school energy life cycle cumulative cost baseline in Table 5.6 is graphically depicted in Figure 5.6 below.

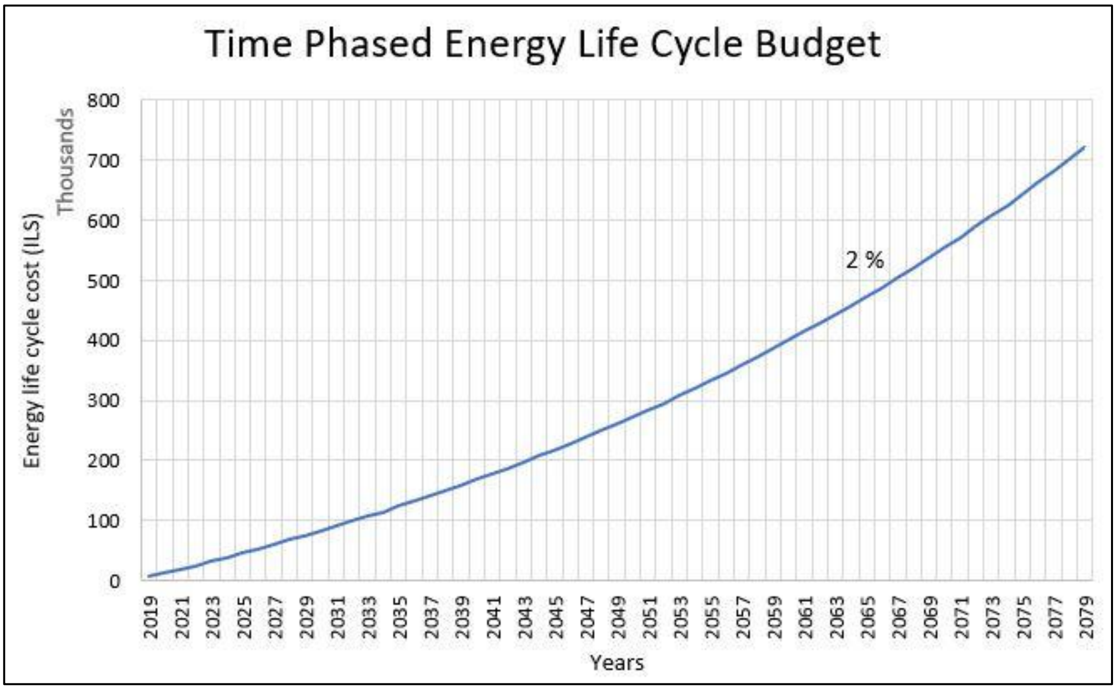

Figure 5.6: Energy life cycle cost baseline for Aqqaba green school.

It can be noticed from Figure 5.6 that the energy life cycle cost curve is affected exponentially by the energy price inflation.

Aqqaba green school energy life cycle cost analysis has been repeated using the same inflation scenarios that were used in estimating public schools' energy life cycle cost analysis in the previous section. The results were tabulated in Table 5.7 below. See Appendix B for the full calculations of the different inflation scenarios that were used in estimating the energy life cycle cost for Aqqaba green school.

Table 5.7: Estimated energy life cycle cost for Aqqaba green school with different energy inflation scenarios.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Interest rate (%)	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Energy price inflation Rate (%)	-2.00%	-1.00%	0.00%	2.00%	3.00%	5.00%	7.00%
Period of analysis (Year)	60.00	60.00	60.00	60.00	60.00	60.00	60.00
Buildings average annual energy consumption (kWh/Year)	8,895.50	8,895.50	8,895.50	8,895.50	8,895.50	8,895.50	8,895.50
Average energy price tariff (ILS/kWh)	0.692	0.692	0.692	0.692	0.692	0.692	0.692
Inflation adjusted i (nominal discount rate)	2.90%	3.95%	5.00%	7.10%	8.15%	10.25%	12.35%
Constant annual energy cost (ILS/Year)	6,155.69	6,155.69	6,155.69	6,155.69	6,155.69	6,155.69	6,155.69
Life cycle energy budget (ILS)	218,033.90	282,124.46	375,497.09	722,262.93	1,039,973.29	2,291,535.03	5,364,479.53
NPV(ILS)	118,900.86	117,699.84	116,522.84	114,238.08	113,128.97	110,974.13	108,899.85

Table 5.7 shows the energy life cycle cost of Aqqaba green school throughout the whole building life cycle at different energy inflation rates. In the real terms (excluding the effect of energy price inflation), Aqqaba energy life cycle cost throughout the whole building life cycle is around 375,497.09 ILS which is equivalent to 116,522.84 ILS in the present terms. The cost is about 722,262.93 ILS at 2% average annual energy price increase, or 114,238.08 ILS in the present value. The cost reaches 5,364,479.53 ILS at 7% average annual increase of energy prices (equals 108,899.85 ILS in the present value). The energy life cycle calculations in Table 5.7 at different energy inflation scenarios are represented graphically in Figure 5.7 below.

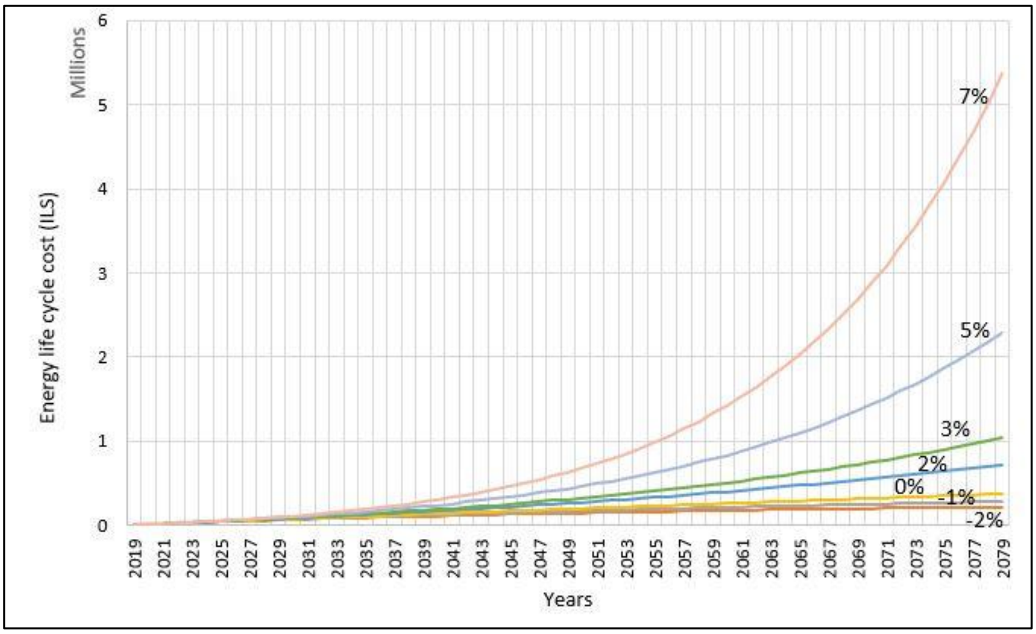

Figure 5.7: Energy life cycle cost baseline for Aqqaba green school using different inflation scenarios.

From Figure 5.7, it can be observed that when the energy inflation rate increases, its exponential effect becomes more apparent on Aqqaba green school energy life cycle cost.

In order to quantify the cost saving associated with reduced energy consumption in Aqqaba green school compared to public school in west bank/ Palestine, calculations throughout the whole life cycle of concrete structures at different energy inflation rates are presented in Table 5.8 below.

Table 5.8: Life cycle energy cost saving of Aqqaba green school at different inflation rates.

Energy price inflation rate scenario (%)	Energy life cycle cost for public schools in West Bank/Palestine (ILS)	Energy life cycle cost for Aqqaba green school (ILS)	Life cycle cost savings (ILS)	NPV of life cycle cost savings (ILS)
-2%	231,348.95	218,033.90	13,315.05	7,261.12
-1%	299,353.43	282,124.46	17,228.97	7,187.77
0%	398,428.21	375,497.09	22,931.12	7,115.90
2%	766,370.59	722,262.93	44,107.66	6,976.37
3%	1,103,483.11	1,039,973.29	63,509.82	6,908.03
5%	2,431,476.10	2,291,535.03	139,941.07	6,777.05
7%	5,692,081.33	5,364,479.53	327,601.80	6,650.37

According to Table 5.8, from life cycle perspective, at 2 % inflation rate of energy cost, Aqqaba green school saves in the nominal terms around 44,107.66 ILS compared to the public schools’ energy LCC baseline, this corresponds to a saving of percentage of 5.76%.

It can also be observed that Aqqaba green school savings increased to 327,601.80 ILS at 7% average annual increase in energy price, representing 6,650.37 ILS at the equivalence present value. While in the real term Aqqaba green school saves about (398,428.21-375,497.09) = 22,931.12 ILS which represents (123,638.74-116,522.84 = 7,115.90 ILS) at the equivalence present value. Aqqaba green school energy life cycle cost savings at different scenarios for energy price inflation rates are graphically represented in Figure 5.8 below.

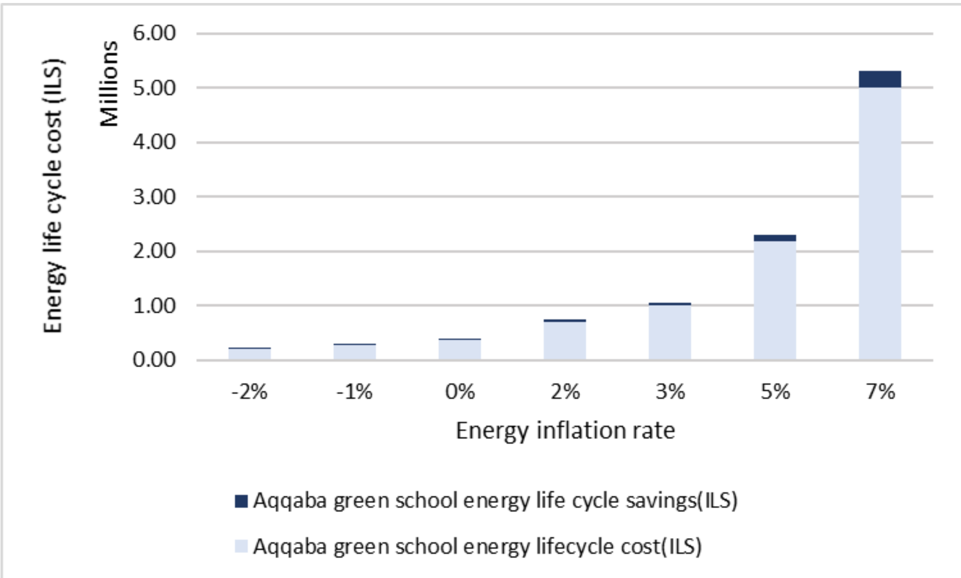

Figure 5.8: Aqqaba life cycle energy cost saving at different inflation rates.

From Figure 5.8, it can be observed that due to the exponential effect of energy price inflation rate, the energy life cycle cost saving of Aqqaba green school increases very rapidly as the energy inflation rate increases.

When taking into account Aqqaba green school PV-system savings from a life cycle perspective, it indicates that Aqqaba green school has a total savings of (44,107.66 ILS+284,187.70 ILS) =328,295.36 ILS. This represents an equivalent present value of (6,976.37 ILS + 44,949.08 ILS) = 51,925.45 ILS.

This compare with the public (non-green) schools energy life cycle cost baseline, were a saving of 42.83% realized from Aqqaba green school PV-system.

In order to determine whether this is economically feasible or not, the following comparison should have been followed:

1. If the additional costs of the green features and the installed PV-system in Aqqaba green school were more than 51,925.45 ILS, then the return is considered economically not feasible.

2. If the additional costs of the green features and the installed PV-system in Aqqaba green school were less than 51,925.45 ILS, then the return is considered economically feasible.

And this does not fall within the objectives of the research.

Due to the fact that the electricity prices of Jerusalem Electricity company and of Northern Electricity Distribution company are different, two baselines for public schools in West Bank were established, the first pertains to Ramallah public schools, and the second for both Nablus and Jenin public schools. Doing so allowed the determination of the effect of electricity prices on the energy life cycle cost baseline for two cities in West Bank.

5.4 Energy Life Cycle Cost Baseline for Public Schools in Ramallah City

In order to obtain the energy life cycle cost baseline for public schools that are located in Ramallah city, the same elements and calculations that were used in section 5.2 were repeated in this section.

The arithmetic mean of the 38 public schools that are located in Ramallah city was 11,578.78 kWh/year, this corresponds to a building energy index (BEI) of 8.95 kWh/m^2/year as indicated in section 5.6. This means that Aqqaba green school consumed less energy than the public (non-green) schools that are located in Ramallah city by 2.63 kWh/m^2/year, this corresponds to a saving percentage of 29.39%.

To calculate the annual energy cost (ILS/Year) that is needed to perform the LCC calculations, the annual energy consumption for each school was multiplied by the electricity price tariff of Jerusalem District Electricity company. Notice that Jerusalem District Electricity company lists Ramallah public schools under the commercial facilities category with an electricity price tariff of 0.6310 ILS/kWh for the year 2018. Therefore, the constant annual energy cost for public schools that are located in Ramallah city was 7,306.21 ILS/year.

Thereafter, the energy life cycle cost analysis for public schools that are located in Ramallah city has been performed using the same inflation scenarios that were used in estimating the energy life cycle cost general baseline for public schools in West Bank/ Palestine in the previous section (section 5.2). The results are tabulated in Table 5.9 below.

Table 5.9: Estimated energy LCC for public schools that are located in Ramallah city using different energy inflation scenarios.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Interest rate (%)	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Energy price inflation Rate (%)	-2.00%	-1.00%	0.00%	2.00%	3.00%	5.00%	7.00%
Period of analysis (Year)	60.00	60.00	60.00	60.00	60.00	60.00	60.00
Buildings average annual energy consumption (kWh/Year)	11,578.78	11,578.78	11,578.78	11,578.78	11,578.78	11,578.78	11,578.78
Average energy price tariff (ILS/kWh)	0.6310	0.6310	0.6310	0.6310	0.6310	0.6310	0.6310
Inflation adjusted i (nominal discount rate)	2.90%	3.95%	5.00%	7.10%	8.15%	10.25%	12.35%
Constant annual energy cost (ILS/Year)	7,306.21	7,306.21	7,306.21	7,306.21	7,306.21	7,306.21	7,306.21
Life cycle energy budget (ILS)	258,785.20	334,854.51	445,678.81	857,256.40	1,234,347.94	2,719,830.95	6,367,119.52
NPV(ILS)	141,123.84	139,698.35	138,301.36	135,589.57	134,273.17	131,715.59	129,253.61

Table 5.9 shows the energy life cycle cost for public schools that are located in Ramallah city throughout the whole building life cycle at different energy inflation rates. In real terms, the energy life cycle cost throughout the whole building life cycle is around 445,678.81 ILS which represents 138,301.36 ILS in the present value. Compared to the energy life cycle cost baseline for public schools in West Bank/Palestine, the real terms energy life cycle cost for public schools that are located in Ramallah city was higher by 47,250.60 ILS.

In nominal terms, the costs are about 857,256.40 ILS at 2% average annual energy price increase (135,589.57 ILS in the present value). Comparing to the energy life cycle cost baseline for public schools in West Bank/Palestine, at 2% inflation rate the energy life cycle cost for public schools that are located in Ramallah city was higher by 90,885.81 ILS, and reaches up to 675,038.19 ILS at 7% inflation rate.

On the other hand, when decreasing the average annual energy price to be -2%, the energy life cycle cost throughout the whole building life cycle decreases to be around 258,785.20 ILS, which equals 141,123.84 ILS in the present value. Comparing to the energy life cycle cost baseline for public schools in West Bank/Palestine, the energy life cycle cost for public schools that are located in Ramallah city was higher by 27,436.25 ILS.

5.5 Energy Life Cycle Cost for Public Schools in Nablus and Jenin Cities

For obtaining the energy life cycle cost baseline for public schools that are located in Nablus and Jenin cities, the same elements and calculations that were used in section 5.2 were repeated in this section.

The arithmetic mean of the selected 65 public schools that are located in Nablus and Jenin cities was 9,659.75 kWh/year, this corresponds to a building energy index (BEI) of 7.99 kWh/m^2/year as indicated in section 5.6. This means that Aqqaba green school consumed less energy than the public (non-green) schools that are located in Nablus and Jenin cities by 1.67 kWh/m^2/year, this corresponds to a saving percentage of 20.90%.

For the purpose of calculating the constant annual energy cost (ILS/Year) that is needed for performing the LCC calculations, the annual energy consumption for each school was multiplied by the electricity price tariff of Northern Electricity Distribution company.

Notice that Northern Electricity Distribution company lists Nablus and Jenin public schools under the pre-payment household facilities category with an electricity price tariff of 0.6215 ILS/kWh for the year 2018. Therefore, the constant annual energy cost for public schools that are located in Nablus and Jenin cities was 6,003.42 ILS/year.

Thereafter, the energy life cycle cost analysis for public schools that are located in Nablus and Jenin cities has been performed using the same inflation scenarios that were used in estimating the energy life cycle cost general baseline for public schools in West Bank/ Palestine in section 5.2. The results are tabulated in Table 5.10 below.

Table 5.10: Estimated energy LCC for public schools that are located in Nablus and Jenin cities with all used energy inflation scenarios.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Interest rate (%)	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Energy price inflation rate (%)	-2.00%	-1.00%	0.00%	2.00%	3.00%	5.00%	7.00%
Period of analysis (Year)	60.00	60.00	60.00	60.00	60.00	60.00	60.00
Buildings average annual energy consumption (kWh/Year)	9,659.75	9,659.75	9,659.75	9,659.75	9,659.75	9,659.75	9,659.75
Average energy price tariff (ILS/kWh)	0.6215	0.6215	0.6215	0.6215	0.6215	0.6215	0.6215
Inflation adjusted i (nominal discount rate)	2.90%	3.95%	5.00%	7.10%	8.15%	10.25%	12.35%
Constant annual energy cost (ILS/Year)	6,003.42	6,003.42	6,003.42	6,003.42	6,003.42	6,003.42	6,003.42
Life cycle energy budget (ILS)	212,640.51	275,145.70	366,208.62	704,396.70	1,014,248.03	2,234,850.56	5,231,781.28
NPV(ILS)	115,959.67	114,788.36	113,640.48	111,412.23	110,330.56	108,229.02	106,206.05

Table 5.10 shows the energy life cycle cost for public schools that are located in Nablus and Jenin cities throughout the whole building life cycle at different energy inflation rates. In real terms, the energy life cycle cost throughout the whole building life cycle is around 366,208.62 ILS which equals 113,640.48 ILS in the present value. Comparing to the energy life cycle cost baseline for public schools in West Bank/Palestine, in the real terms the energy life cycle cost for public schools that are located in Nablus and Jenin cities was 32,219.59 ILS lower.

In the nominal terms, the cost is about 704,396.70 ILS at 2% average annual energy price increase (111,412.23 ILS in the present value). At 2% inflation rate, the energy life cycle cost for public schools that are located in Nablus and Jenin cities is 61,973.89 ILS lower than that of the public schools in West Bank. While at 7% inflation rate, the difference become 460,300.05 ILS.

On the other hand, when decreasing the average annual energy price to be -2%, the energy life cycle cost throughout the whole building life cycle decreases to be about 212,640.51 ILS (115,959.67 ILS in the equivalence present value). In this case comparing to the energy life cycle cost baseline for public schools in West Bank/Palestine, the energy life cycle cost for public schools that are located in Nablus and Jenin cities is 18,708.44 ILS lower than that of West Bank public schools.

A summary of the results of the three previous public schools' baselines are listed in Table 5.11 below.

Table 5.11: Energy LCC baselines for public schools with different energy inflation scenarios.

				Energy LCC baseline for Aqqaba green school		General energy LCC baseline for public schools in West Bank/Palestine		Energy LCC baseline for public schools that are located in Ramallah city		Energy LCC baseline for public schools that are located in Nablus and Jenin cities	
Number of schools				1		103		38		65	
Buildings average annual energy consumption (kWh/Year)				8895.5		10367.63		11,578.78		9,659.75	
Average energy price tariff (ILS/kWh)				0.692		0.6254		0.631		0.6215	
Constant annual energy cost (ILS/Year)				6155.69		6531.61		7,306.21		6,003.42	
Interest rate (%)	**Energy price inflation rate (%)**	**Inflation adjusted i (nominal discount rate)**	**Period of analysis (Year)**	**Life cycle energy budget (ILS)**	**NPV(ILS)**	**Life cycle energy budget (ILS)**	**NPV(ILS)**	**Life cycle energy budget (ILS)**	**NPV(ILS)**	**Life cycle energy budget (ILS)**	**NPV(ILS)**
5%	-2.00%	2.90%	60	218,033.90	118,900.86	231,348.95	126,161.98	258,785.20	141,123.84	212,640.51	115,959.67
5%	-1.00%	3.95%	60	282,124.46	117,699.84	299,353.43	124,887.61	334,854.51	139,698.35	275,145.70	114,788.36
5%	0.00%	5.00%	60	375,497.09	116,522.84	398,428.21	123,638.74	445,678.81	138,301.36	366,208.62	113,640.48
5%	2.00%	7.10%	60	722,262.93	114,238.08	766,370.59	121,214.45	857,256.40	135,589.57	704,396.70	111,412.23
5%	3.00%	8.15%	60	1,039,973.29	113,128.97	1,103,483.11	120,037.61	1,234,347.94	134,273.17	1,014,248.03	110,330.56
5%	5.00%	10.25%	60	2,291,535.03	110,974.13	2,431,476.10	117,751.18	2,719,830.95	131,715.59	2,234,850.56	108,229.02
5%	7.00%	12.35%	60	5,364,479.53	108,899.85	5,692,081.33	115,550.22	6,367,119.52	129,253.61	5,231,781.28	106,206.05

After establishing the needed energy life cycle cost baselines in the preceding sections, a technical comparison of Aqqaba green school efficiency with public schools in West Bank/Palestine is held in the next section.

5.6 Performance of Aqqaba Green School Compared with Public Schools in West Bank/Palestine with Similar Categories of Students Numbers and Areas.

The building energy index BEI (or energy efficiency index EEI) are the same performance indicator for measuring the total annual end-use energy consumption in a building (Denny & Malley, 2014). The building energy index is calculated by dividing the total annual energy used in a given building (kWh/ year) by the building gross area (m^2) (Denny & Malley, 2014), and it is expressed as kWh/m^2/year. According to Moghimi et al.(2011) the building energy index can be calculated using the occupied air conditioning area.

Due to the unavailability of conditioned areas in the public schools in West Bank/Palestine, and since that the source of energy consumption in public schools comes mainly from lighting and appliances (computers, laboratories machines, and tools), the BEI was calculated based on the gross area of the school building.

In this research the Building Energy Index (BEI) was calculated to compare the energy efficiency of Aqqaba green school and that with public schools in West Bank/Palestine.

For calculating the green school building energy index, the total annual energy consumption of the school (8895.50 kWh/year) was divided by its gross floor area (1408.00 m^2). Also, the BEI per student for Aqqaba green school was calculated by dividing the total annual energy consumption of Aqqaba green school (8895.50 kWh/year) by the number of its students (151 student). Table 5.12 below represents Aqqaba green school BEI calculations.

Table 5.12: Aqqaba green school building energy index.

School name	Aqqaba green school
Total number of students	151.00
School building area(m^2)	1,408.00
Annual electricity consumption (kWh)	8,895.50
Building energy index per meter square (kWh/m^2/year)	6.32
Building energy index per student (kWh/Student/year)	58.91

By dividing each public school annual energy consumption over its gross floor area, the BEI for each school was calculated. Then the average of the BEI for the public schools was calculated in order to compare the results with those of Aqqaba green school BEI. See Appendix C for the full BEI (kWh/m^2/year) calculations for public schools in West Bank/Palestine.

Also, the Building energy index per student was calculated for the public schools by dividing each public school annual energy consumption over its number of students. Then the average of the BEI per students for the public schools was calculated in order to compare the results with those of Aqqaba green school. See Appendix C for the full BEI (kWh/student/year) calculations for public schools.

The baseline BEI according to total energy consumption over the gross floor area of public schools in West Bank/Palestine averaged 8.34 kWh/m^2/year, while Aqqaba green school BEI was 6.32 kWh/m^2/year. This is lower than the public schools BEI baseline by 24.22%. The lower BEI (kWh/m^2/year) value of Aqqaba green school compared to BEI of public schools in West Bank/Palestine is due to the difference in the gross area of Aqqaba green school compared to the areas mean value of public schools where Aqqaba green school has an area that is 270.60 m^2 lower than that of the public schools.

Comparing the BEI (kWh/m^2/year) for public schools in Palestine with other countries reveals that the energy consumption in schools in Palestine is very low. For example: In Taiwan, Wang (2016) reported a range from 17 to 26 kWh/m^2/year and a range from 289 – 734 kWh/student/year. Also in a survey for 9 schools conducted in Daegu in South Korea, Kim et al., (2019) reported that the average annual energy consumption per unit area is 133 kWh/m^2/year, and 700-1800 kWh/student/year. In Taiwan, Hernandez et al., (2008) reported a median of 96 kWh/m^2/year and an upper quartile of 65 kWh/m²/year as a result of analyzing a sample consists of 88 schools in Ireland.

The reason of the low energy consumption of public schools in Palestine is due to the unavailability of conditioned areas in the public schools in West Bank/Palestine, and since that the source of energy consumption in public schools comes mainly from lighting and appliances (computers, laboratories machines, and tools).

It worth to be mentioned that in a previous master degree research conducted by Hodiri (2018) in order to evaluate the actual performance of Aqqaba green school. He reported that Aqqaba green school BEI was 24.79% less than that of the public schools.

The calculated Aqqaba green school BEI of this research agrees very well with Hodari's findings. The BEI calculations can be seen in Table 5.13 below.

Table 5.13: BEI for public schools in West Bank/Palestine compared to Aqqaba green school.

	Public schools in West Bank/Palestine	**Public schools in Ramallah city**	**Public schools in Nablus and Jenin cities**	**Aqqaba green school**
Building energy index per meter square (kWh/m²/year)	8.34	8.95	7.99	6.32
Building energy index per student (kWh/Student/year)	35.44	38.44	33.69	58.91

Furthermore, according to Table 5.13 above, the baseline BEI per student for public schools in West Bank/Palestine was 35.44 kWh/student/year, while Aqqaba green school BEI was 58.91 kWh/student/year. This is higher than the public schools BEI baseline by 39.84%. The higher BEI value of Aqqaba green school is due to the difference in the number of students of Aqqaba green school compared to the number of students mean value of public schools which is less than the mean value of student by 127. Accordingly, it is worth to be mentioning that Hodiri (2018) also reported that Aqqaba green school BEI was higher than that of the public schools BEI baseline by 107%, which confirms Hodiri research results.

Furthermore, in order to compare Aqqaba green school energy efficiency with public schools that have the same areas and number of students, the BEI for public schools that have the same areas and number of students as Aqqaba green school was recalculated.

18 schools from the research sample were identified where the area of each school was 1408.00 m^2 ±250 m^2. See Appendix C for the full BEI (kWh/ m^2/year) calculations of public schools with same area ±250 m^2 as Aqqaba green school area.

Also, the Building energy index per student was calculated for public schools that have the same number of students as Aqqaba green school (±50 student). From the research sample, 16 schools have similar number of students (±50 student) similar to that of Aqqaba school. See Appendix C for the full BEI for public schools with same number of students ±50 student as Aqqaba green school number of students.

Furthermore, two schools from the sample have similar number of students (±50) and similar area (±250 m^2) those of Aqqaba school. Table 5.14 represents the calculations of building energy index for the public schools with same areas and number of students.

Table 5.14: BEI for public schools with same areas (±250 m^2) and number of students (±50) as Aqqaba green school.

	Public schools with same areas as Aqqaba green school (±250 m^2)	Public schools with same number of students as Aqqaba green school (±50).	Public schools with same Areas (±250 m^2) and number of students (±50) as Aqqaba green school
Number of schools	18	16	2
BEI ($kWh/m^2/year$)	6.43	-	5.26
BEI (kWh/Student/year)	-	36.09	43.59

Table 5.14, shows that the BEI ($kWh/m^2/year$) for Aqqaba green school was lower than the BEI ($kWh/m^2/year$) for public schools with same areas as Aqqaba green school (±250 m^2) by 1.71%, which means that Aqqaba green school energy performance is better than public schools with same Areas. Furthermore, Aqqaba green school BEI per student was higher than public schools by 38.74%.

On the other hand, the BEI per area and BEI per student for Aqqaba green school were higher by 19.01% and 26.01% respectively than the BEI of public schools with both same areas and students' numbers.

5.7 Chapter Summery

This chapter provided a detailed description of data analyses that was used for obtaining an energy life cycle cost baseline for public schools in West Bank/Palestine. In the first section of this chapter, the monthly energy consumption data for the selected public schools was converted to annual consumptions, then a definition of the energy consumption outliers was conducted. In the second section, the needed elements for the energy LCC baseline were identified and selected, seven energy inflation/deflation scenarios were used in calculating the energy LCC baselines for public schools in West Bank, Aqqaba green school, Ramallah public schools, and Nablus and Jenin cities public schools.

Furthermore, a comparison between Aqqaba green school and public schools' energy LCC baselines for quantifying the green school energy savings was obtained. This chapter concluded with conducting an economic performance of Aqqaba green school compared with public schools' BEI per m^2 and per student.

Chapter Six
Conclusions and Recommendations

This chapter highlights the main conclusions and recommendations that were drawn from this research which aimed at conducting an estimation of the life cycle cost of energy in public schools in Palestine and quantifying the life cycle cost saving associated with reduced energy consumption in the first green school in Palestine (Aqqaba green school).

in addition, this chapter presents the limitations that faced the preparation of this research, ending up with some suggestions for future work related to this study.

6.1 Research Conclusions

Depending on the outcome of this work, the following conclusions were drawn:

- The Palestinian public (non-green) schools average annual energy consumption was 10,367.63 kWh/year, this corresponds to BEI of 8.34 kWh/m²/year. While the average annual energy consumption of Aqqaba green school was 8,895.50 kWh/year, this corresponds to BEI of 6.32 kWh/m²/year. This means that Aqqaba green school consumed less energy than the public (non-green) schools by 2.02 kWh/m²/year, this corresponds to a saving percentage of 24.22%. It is worth noting that this saving calculated based on the building energy index, this is because the BEI normalizes the energy consumption based on the area and this secures more meaningful and fair comparison.

- The Palestinian public (non-green) schools that are located in Ramallah city have an average annual energy consumption of 11,578.78 kWh/year, this corresponds to BEI of 8.95 kWh/m^2/year. This means that Aqqaba green school consumed less energy than the public (non-green) schools that are located in Ramallah city by 2.63 kWh/m^2/year, this corresponds to a saving percentage of 29.39%.

- The Palestinian public (non-green) schools that are located in Nablus and Jenin cities have an average annual energy consumption of 9,659.75 kWh/year, this corresponds to a building energy index (BEI) of 7.99 kWh/m^2/year. This means that Aqqaba green school consumed less energy than the public (non-green) schools that are located in Nablus and Jenin cities by 1.67 kWh/m^2/year, this corresponds to a saving percentage of 20.90%.

- The Palestinian public (non-green) schools with same areas as Aqqaba green school (±250 m^2) have a building energy index (BEI) of 6.43 kWh/m^2/year. This means that Aqqaba green school energy performance comparing to public (non-green) schools that have similar gross floor area as Aqqaba green school almost the same.

- Aqqaba green school is supplied with a grid connected PV-system with a capacity of 15 kWp, which yields savings from the generated energy of 2,422.0755 ILS per year.

- From a life cycle perspective, using 60 years period of analysis from 2019 to 2079 and a different inflations scenario, an energy life cycle cost baseline for public (non-green) schools in West Bank/Palestine was found to be 766,370.59 ILS at 2% inflation rate, which represents an equivalent present value of 121,214.45 ILS. While the energy life cycle cost for Aqqaba green school was 722,262.93 ILS at 2% inflation rate, which represents an equivalent present value of 114,238.08 ILS.

This indicates that Aqqaba green school has a savings of 44,107.66 ILS (present value of 6,976.37 ILS) comparing to the public (non-green) schools energy life cycle cost baseline, representing a saving of 5.76% without taking into account the savings from Aqqaba green school PV-system.

- The savings from Aqqaba green school PV-system from a life cycle perspective are 284,187.70 ILS at 2% inflation rate (present value of 44,949.08 ILS). This indicates that Aqqaba green school has a savings of 328,295.36 ILS (present value of 51,925.45 ILS) comparing to the public (non-green) schools energy life cycle cost baseline. This represents a saving percentage of 42.83% when taking into account the savings from Aqqaba green school PV-system.

- An energy life cycle cost baseline for public (non-green) schools located only in Ramallah city/Palestine was found to be 857,256.40 ILS at 2% inflation rate (present value of 135,589.57 ILS). This is higher than the general energy life cycle cost baseline for all public (non-green) schools in West Bank/Palestine by 11.86%.

In comparison the energy life cycle cost for Aqqaba green school at 2% inflation rate has a savings of 134,993.47 ILS (15.75% lower) without taking into account the savings from Aqqaba green school PV-system.

- An energy life cycle cost baseline for public (non-green) schools located only in Nablus and Jenin cities/Palestine was found to be 704,396.70 ILS at 2% inflation rate (present value of 111,412.23 ILS). This is about 8.09% less than the general energy life cycle cost baseline for all public (non-green) schools in West Bank/Palestine.

In the meantime, Aqqaba green school energy life cycle cost is higher by 17,866.23 ILS (or 2.47% more) without taking into account the savings from Aqqaba green school PV-system.

- The Building Energy Index (BEI) of public (non-green) schools in West Bank/Palestine was 35.44 kWh/student/year, while the Building Energy Index of Aqqaba green school was 58.91 kWh/student/year, which is higher than the public (non-green) schools' BEI by 39.84%.

In summary, as can be seen from the conclusion above that the economic performance in the green school is better than non-green schools and it can be concluded that the PV-system which is installed in the green school forms the major share (86.56%) of the economic performance of the green school. Accordingly, installing PV-systems for the non-green schools seems to be valuable solution for saving energy in such buildings.

6.2 Research Limitations

During this study, several issues affected the generalizability of this research results. Some of these issues are summarized below:

1. Unavailability of historical electricity price records in Palestine, that affected the future forecast of electricity price. To overcome this limitation, different scenarios for future electricity price are proposed.

2. Excluding Gaza strip from this research, due to the political obstacles that faces entering Gaza, affects the generalizability of research results.

3. In this research a random sample of energy consumption in public schools from all over the West Bank was analyzed, the results would have been more comprehensive if the entire population data were used.

6.3 Recommendations

Based on the previous conclusions and research findings, the researcher recommends the following:

1. Trying to collect the energy data for all the Palestinian public (non-green) schools and applying the LCC analysis on it.

2. Trying to develop a database for the Palestinian public schools containing construction costs, operating costs (water and sewerage costs), maintenance costs and end of life cost, in order to have a complete LCC study.

3. Trying to benefit from the economic advantages of the PV-systems installation over all the governmental school in Palestine.

6.4 Future Work

In line with this research objective of establishing an energy life cycle cost baseline for public schools in Palestine, the following future work is recommended:

1. To conduct an estimation of the life cycle cost of water in public schools in Palestine.

2. To quantify the life cycle cost saving associated with reduced water consumption in Aqqaba green school compared to public (non-green) schools in Palestine.

References

- Abd Rashid, A. F., & Yusoff, S. (2015). A **review of life cycle assessment method for building industry.** Renewable and Sustainable Energy Reviews, 45, 244–248. https://doi.org/10.1016/j.rser.2015.01.043

- Abdelfattah, A. (2017). **RELATION BETWEEN GREEN BUILDINGS AND SUSTAINABLE DEVELOPMENT PRACTICES.** The 1st International Conference: Towards A Better Quality of Life, 1–11. Retrieved from

  https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3163476

- Abu-hafeetha, M. F. F. (2009). **Planning for Solar Energy as an Energy Option for Palestine.**

- Abu Dhabi Urban Planing Council. (2010). **The Pearl Rating System for Estidama Building Rating System**. Version1.0, April 2010.

- Ajay, S., & Micah, B. (2014). ***SAMPLING TECHNIQUES & DETERMINATION OF SAMPLE SIZE IN APPLIED STATISTICS RESEARCH : AN OVERVIEW***. **International Journal of Economics, Commerce and Management,** *II*(11), 1–22.

- Akbarnezhad, A. (2014). **Sustainable Structures Symposium** (C. Griffin & J. Mollner, Eds.). Portland: School of Architecture, Portland State University.

- Bartlett, J. E., Kotrlik, J. W., & Higgins, C. C. (2001). **Organizational Research : Determining Appropriate Sample Size in Survey Research**. *19*(1), 43–50.

- BRE Global. (2016). **BREEAM International New Construction 2016.** Technical Manual SD233_Issue :1.0.

- Breysse, J., Jacobs, D., Dixon, S., Kawecki, C., & Solutions, H. H. (2011). **Health Outcomes and Green Renovation of Affordable Housing**. (May). https://doi.org/10.2307/41639267

- Brundtland, G. H. (1987). **Our Common Future: Report of the World Commission on Environment and Development**. In United Nations Commission (Vol. 4). https://doi.org/10.1080/07488008808408783

- Buyle, M., Braet, J., & Audenaert, A. (2012). ***Review on LCA in the Construction Industry: Case Studies.*** **International Journal of Energy and Environment**, *6*(4), 98–104.

- Cabeza, L. F., Rincón, L., Vilariño, V., Pérez, G., & Castell, A. (2014). **Life cycle assessment (LCA) and life cycle energy analysis (LCEA) of buildings and the building sector: A review**. Renewable and Sustainable Energy Reviews, 29, 394–416. https://doi.org/10.1016/j.rser.2013.08.037.

- Chan, A. P. C., Darko, A., Ameyaw, E. E., & Owusu-Manu, D.-G. (2016). ***Barriers Affecting the Adoption of Green Building Technologies***. **Journal of Management in Engineering,** *33*(3), 04016057. https://doi.org/10.1061/(asce)me.1943-5479.0000507

- Ciravoglu, A. (2005). **A RESEARCH ON EMBODIED ENERGY OF BUILDING MATERIALS : REFLECTIONS ON TURKEY.** *2005*(September), 27–29.

- Cochran, W. G. (1963). **Sampling Technique***s* (2nd Ed). NewY ork: John Wiley and Sons Inc.

- Connor, S., Meek, C., Bassok, A., & Kopca, C. (2015). **The value of green.** In Runstad Center for Real Estate Studies (Vol. 40).

- Creswell, J. W. (2010). **Educational Research: Planning, Conducting and Evaluating Quantitative and Qualititave Research** (Fourth Edi). Boston, USA: PEARSON.

- Curran, M. A. (2013). L**ife Cycle Assessment: A review of the methodology and its application to sustainability**. Current Opinion in Chemical Engineering, 2(3), 273–277. https://doi.org/10.1016/j.coche.2013.02.002

- Davis Langdon. (2007). *L***ife cycle costing (LCC) as a contribution to sustainable construction : a common methodology Literature Review**.

- Denny, E., & Malley, M. O. (2014). **Building a sustainable energy future : Supply and demand options.** (May). https://doi.org/10.1109/PES.2008.4596260

- Ding, G. K. C. (2008). ***Sustainable construction--the role of environmental assessment tools.*** **Journal of Environmental Management,** *86*(3), 451–464.

https://doi.org/10.1016/j.jenvman.2006.12.025

- Du Plessis, C. (2002). **Agenda 21 for: Sustainable construction in developing countries - a discussion document.** Retrieved from http://researchspace.csir.co.za/dspace/handle/10204/3511

- Dwaikat, L. N., & Ali, K. N. (2016). **Green buildings cost premium: A review of empirical evidence.** (January).

https://doi.org/10.1016/j.enbuild.2015.11.021

- Dwaikat, L. N., & Ali, K. N. (2018a). ***Green buildings life cycle cost analysis and life cycle budget development: Practical applications***. **Journal of Building Engineering,** 18 (October 2017), 303–311. https://doi.org/10.1016/j.jobe.2018.03.015

- Dwaikat, L. N., & Ali, K. N. (2018b). ***The economic benefits of a green building – Evidence from Malaysia.*** **Journal of Building Engineering,** 18 (February), 448–453.

https://doi.org/10.1016/j.jobe.2018.04.017

- Electric, S. (2006). **Sustainable Solutions : The Impact of the Green Building Movement.** (December).

- Elgendy, K. (2010). **Comparing Estidama's Pearls Rating System to LEED and BREEAM.** Retrieved April 5, 2020, from http://www.carboun.com/sustainable-urbanism/comparing-estidama's-pearls-rating-method-to-leed-and-breeam/

- Filippi, M., & Sirombo, E. (2015). **Green rating of existing school facilities.** Energy Procedia, 78, 3156–3161. https://doi.org/10.1016/j.egypro.2015.11.773

- Fowler, Kim M., & Rauch, E. M. (2008). **Assessing Green Building Performance: a Post Occupancy Evaluation of 12 GSA Buildings**. In A post occupancy evaluation of 12 GSA buildings. Retrieved from Pacific Northwest National Laboratory website: http://www.capitalmarketspartnership.com/UserFiles/Admin GSA June 2008 - Assessing Green Building Performance. pdf%0Apapers2://publication/uuid/7953C7F9-0722-40F9-83F5-EFBF71C6D24D

- Fowler, Kimberly M., Rauch, E. M., Henderson, J. W., & Kora, A. R. (2010). **Re-Assessing Green Building Performance: A Post Occupancy Evaluation of 22 GSA Buildings.** https://doi.org/10.2172/1029438.

- Fu, F., Pan, L., Ma, L., & Li, Z. (2013). **A simplified method to estimate the energy-saving potentials of frequent construction and demolition process in China**. Energy, 49(1), 316–322. https://doi.org/10.1016/j.energy.2012.10.021

- Fuller, S. (2016). **Life Cycle Cost Analysis.** National Institute of Standards and Technology, 10(Lcc), 1–5. Retrieved from http://www.nist.gov/index.html%5Cnhttp://www.slideshare.net/nirjhar_jgec/life-cycle-cost-analysis

- Giddings, B., Hopwood, B., & O'Brien, G. (2002). **Environment, economy and society: Fitting them together into sustainable development.** Sustainable Development, *10*(4), 187–196. https://doi.org/10.1002/sd.199

- Global Communities. (2016). **The First Green School in Palestine**. Retrieved May 20, 2019, from https://www.globalcommunities.ps/files/file/Aqqaba Factsheet_AR.PDF

- Green Building Councel in Australia. (2006). **The dollars and sense of green buildings: building the business case for green commercial buildings in Australia.** Australia.

- H. Rustom, N. (2014). **Promoting Green Buildings Practices in Palestine. The Islamic University of Gaza**.

- Haddad, H. (2010). **a Framework of Sustainable Design for the Region of Palestine**. (December).

- Haj Hussein, Muhannad; Barlet, Aline; Baba, Mutasim; Semidor, C. (2016). **Evaluation for Environmental Comfort Performance in the Palestinian Schools**. PLEA 2016 Los Angeles - 36th International Conference on Passive and Low Energy Architecture. Cities, Buildings, People: Towards Regenerative Environments, (September).

- Hák, T., Janouˇsková, S., & Moldan, B. (2016). **Sustainable Development Goals : A need for relevant indicators**. 60, 565–573. https://doi.org/10.1016/j.ecolind.2015.08.003

- Handl, G. (2012). **Declaration of the United Nations Conference on the Human Environment (Stockholm Declaration), 1972 and the Rio Declaration on Environment and Development, 1992.** United Nations Audiovisual Library of International Law, 1–11.

- Heralova, R. S. (2017). **Life Cycle Costing as an Important Contribution to Feasibility Study in Construction Projects**. Procedia Engineering, 196(June), 565–570.

https://doi.org/10.1016/j.proeng.2017.08.031.

- Hernandez, P., Burke, K., & Lewis, J. O. (2008). **Development of energy performance benchmarks and building energy ratings for non-domestic buildings: An example for Irish primary schools**. Energy and Buildings, 40(3), 249–254.

https://doi.org/https://doi.org/10.1016/j.enbuild.2007.02.020

- Hewitt, D., Turner, C., & Frankel, M. (2008). **Green Building Performance Evaluation in the United States: Measured Results from LEED-New Construction Buildings**. Proceedings of the Eighth International Conference for Enhanced Building Operations, *2*, 329–341.

- Hijleh, L. A. (2017). **Final Program Report Local Government and Infrastructure Program.**

- Hodiri, H. (2018). **Assessing the Actual Performance of Green Buildings in Palestine : A Case Study**.

- Howden-chapman, P., Free, S., Pierse, N., & Viggers, H. (2009). **More effective home heating reduces school absences for children with asthma**. (September). https://doi.org/10.1136/jech.2008.086520

- Hussain, A. (2016). **IJREAS Volume 2 , Issue 10 (October 2012).** (October 2012).

- Ibrik, I. H., & Mahmoud, M. M. (2002). E***nergy efficiency improvement and its techno-economical impacts by raising of power factor at industrial sector in Palestine***. **Pakistan Journal of Applied Sciences**, *2*(9), 907–912.

- IFMA. (2015). **Green Building Rating System**. Ess-Sag, 1(November), 1–53.

- Ikediashi, D. I., Ogunlana, S. O., Oladokun, M. G., & Adewuyi, T. (2012). ***Assessing the level of commitment and barriers to sustainable facilities management practice: A case of Nigeria***. **International Journal of Sustainable Built Environment,** 1(2), 167–176. https://doi.org/10.1016/j.ijsbe.2013.06.002

- International Standards Organisation, I. (2006). **Environmental management — Life cycle assessment — Requirements and guidelines.** In Environmental management — Life cycle assessment — Requirements and guidelines (Vol. 2006, pp. 652–668). https://doi.org/10.1007/s11367-011-0297-3

- Ismail, M. S., Moghavvemi, M., & Mahlia, T. M. I. (2013). **Energy trends in Palestinian territories of West Bank and Gaza Strip : Possibilities for reducing the reliance on external energy sources.** Renewable and Sustainable Energy Reviews, 28, 117–129. https://doi.org/10.1016/j.rser.2013.07.047

- ISO15686-5. (2008). **Buildings and Constructed Assets – Service Life Planning – Part 5:Life-cycle costing** *(ISO 15686-5:2008)* (First edit, Vol. 2008). Geneva, Switzerland: International Organization of Standardization.

- Jawad, D., & Ozbay, K. (2006). **the Discount Rate in Life Cycle Cost Analysis of.** 85th Annual Meeting of the Transportation Research Board, (January 2005), 1–19.

- Kates, R. W., Parris, T. M., & Leiserowitz, A. A. (2005). **What is sustainable development? Goals, indicators, values, and practice**. In Environment . Science and Policy for Sustainable Development (Vol. 47). https://doi.org/10.1080/00139157.2005.10524444

- Kats, G. (2013). **Greening our built world: costs, benefits, and strategies.** Choice Reviews Online, 48(02), 48-0678-48–0678. https://doi.org/10.5860/choice.48-0678

- Kats, G., Alevantis, L., Berman, A., & Perlman, J. (2003). **The Costs and Financial Benefits of Green Buildings A Report to California ' s Sustainable Building Task Force**. In Capital E. Retrieved from California Department of Resources Recycling and Recovery website: http://www.usgbc.org/resources/costs-and-financial-benefits-green-buildings-report-california's-sustainable-building-task.

- Kibert, C. J. (2012). **Sustainable Construction:Green building Design and Delivery.** In John Wiley & Sons, Inc. (Third Edit). New Jersey,USA: John Wiley & Sons, Inc., Hoboken, New Jersey.

- Kibert, C. J. (2016). **Introduction to Sustainable Construction**. Sustainable Construction: Green Building Design and Delivery, 2008, 1–18.

- Kim, T., Kang, B., Kim, H., Park, C., & Hong, W.-H. (2019). **The study on the Energy Consumption of middle school facilities in Daegu, Korea**. Energy Reports, 5, 993–1000. https://doi.org/https://doi.org/10.1016/j.egyr.2019.07.015

- Klöpffer, W. (2014). **Background and Future Prospects in Life Cycle Assessment (Edition on).** Springer Netherlands.

- Kothari, C. R. (2004). **Research Methodology: Methods & Techniques. In New Age International (P) Ltd.** https://doi.org/10.1017/CBO9781107415324.004

- Kubba, S. (2010). **LEED Practices, Certification, and Accreditation Handbook.** Retrieved from https://doi.org/10.1016/B978-1-85617-691-0.00010-2.

- Li, Y., Chen, X., Wang, X., Xu, Y., & Chen, P. H. (2017). **A review of studies on green building assessment methods by comparative analysis**. Energy and Buildings, 146(April), 152–159. https://doi.org/10.1016/j.enbuild.2017.04.076

- Liang, X., Hong, T., & Qiping, G. (2016). **Improving the accuracy of energy baseline models for commercial buildings with occupancy data**. Applied Energy, 179, 247–260.

https://doi.org/10.1016/j.apenergy.2016.06.141

- Lysgaard, J. A., Læssøe, J., & Larsen, N. (2015). **Green Flag Eco-Schools and the Challenge of Moving Forward**. Responsible Living, 135–150. Retrieved from

https://link.springer.com/chapter/10.1007%2F978-3-319-15305-6_10#citeas

- Ma, J., & Cheng, J. C. P. (2016). **Estimation of the building energy use intensity in the urban scale by integrating GIS and big data technology.** Applied Energy, 183, 182–192. https://doi.org/10.1016/j.apenergy.2016.08.079

- MAGZAMEN, S., MAYER, A. P., BARR, S., BOHREN, L., DUNBAR, B., MANNING, D., … CROSS, J. E. (2017). **on Green Schools : Infrastructure , Social Environment , Occupant Health**,. *87*(5).

- Mahmoud, M., & Ibrik, I. (2002). ***Power Losses Reduction in Low Voltage Distribution Networks by Improving the Power Factor in Residential Sector.*** **Pakistan Journal of Applied Sciences**, *2*(7), 727–732. https://doi.org/10.3923/jas.2002.727.732

- Masoso, O. T., & Grobler, L. J. (2010). **The dark side of occupants ' behaviour on building energy use**. *42*, 173–177. https://doi.org/10.1016/j.enbuild.2009.08.009

- Matar, M. M., Georgy, M. E., & Ibrahim, M. E. (2008). **Sustainable construction management: Introduction of the operational context space (OCS)**. Construction Management and Economics, 26(3), 261–275. https://doi.org/10.1080/01446190701842972

- Mirzadeh, I., & Birgisson, B. (2015). ***Accommodating energy price volatility in life cycle cost analysis of asphalt pavements***. **Journal of Civil Engineering and Management**, *22*(8), 1001–1008. https://doi.org/10.3846/13923730.2014.945951

- Moghimi, S., Mat, S., Lim, C. H., Zaharim, A., & Sopian, K. (2011). **Building Energy Index (BEI) in Large Scale Hospital : Case Study of Malaysia.** 167–170.

- Morris, P., & Matthiessen, L. F. (2007). C***ost of Green Revisited: Reexamining the Feasability and Cost Impact of Sustainable Design in the Light of Increased Market Adoption***. **South African Journal of Radiology,** 25. https://doi.org/10.4102/sajr.v13i4.483

- Morrissey, J., & Horne, R. E. (2011). **Life cycle cost implications of energy efficiency measures in new residential buildings**. Energy and Buildings, 43(4), 915–924. https://doi.org/10.1016/j.enbuild.2010.12.013

- Naing, L., Winn, T., & Rusli, B. N. (2006). **Practical Issues in Calculating the Sample Size for Prevalence Studies**. Archives of Orofacial Sciences 2006;, 1(Ci), 9–14.

- Najihah, N., Bakar, A., Yusri, M., & Abdullah, H. (2015). **Energy ef fi ciency index as an indicator for measuring building energy performance : A review.** 44, 1–11.

https://doi.org/10.1016/j.rser.2014.12.018

- Palestine Engineers Association. (2013). **Green buildings Guidelines – State of Palestine.** 141.

- **Palestinian Central Bureau of Statistics**. (2018). Energy Balance of Palestine. Ramallah - Palestine.

- **Palestinian Ministry of Education**. (2018). School list in West Bank/Palestine. Ramallah.

- Patz, J. A., Githeko, A. K., McCarty, J. P., Hussein, S., Confalonieri, U., & De Wet, N. (2003). **Climate change and infectious diseases. Climate change and human health: risks and responses**. In World Health Organization. https://doi.org/10.2307/2137486.

- Pe´rez-Lombard, L., Ortiz, J., & Pout, C. (2008). **A review on buildings energy consumption information´.** Energy and Buildings, 40, 394–398. https://doi.org/10.1016/j.enbuild.2007.03.007

- Ramesh, T., Prakash, R., & Shukla, K. K. (2010). **Life cycle energy analysis of buildings : An overview**. *42*, 1592–1600. https://doi.org/10.1016/j.enbuild.2010.05.007

- Rauf, A., & Crawford, R. H. (2015). **Building service life and its effect on the life cycle embodied energy of buildings**. Energy, 79(C), 140–148. https://doi.org/10.1016/j.energy.2014.10.093

- Reidy, R., Davis, M., Coony, R., Gould, S., & Mann, C.Sewak, B. (2005). **GUIDELINES FOR LIFE CYCLE COST ANALYSIS**. (October), 1–28. https://doi.org/10.1002/jrs.1250241114

- Ries, R., Bilec, M. M., Gokhan, N. M., & Needy, K. L. (2006). **The economic benefits of green buildings: A comprehensive case study**. Engineering Economist, *51*(3), 259–295.

https://doi.org/10.1080/00137910600865469

- Salama, M., & Hana, A. R. (2010). G**reen buildings and sustainable construction in the United Arab Emirates**. 26th Annual ARCOM Confrence, 2005(September), 1397–1405.

- Samari, M., Godrati, N., Esmaeilifar, R., Olfat, P., & Shafiei, M. W. M. (2013). **The investigation of the barriers in developing green building in Malaysia.** Modern Applied Science, 7(2), 1–10. https://doi.org/10.5539/mas.v7n2p1

- Saunders, M., Lewis, P., & Thornhill, A. (2008). **Research Methods for Business Students.** In Research methods for business students. https://doi.org/10.1007/s13398-014-0173-7.2

- Sinha, A. ., Gupta, R. ., & Kutnar, A. . (2013). **Sustainable Development and Green Buildings.** Sustainable Development and Green Buildings, 64(1), 45–53. https://doi.org/10.5552/drind.2013.1205

- Statistics Canada. (2012). **Your Guide to the Consumer Price Index.** Otlawa,Ontario: Statistics Canada Publication.

- Swarr, T. E., Hunkeler, D., Klöpffer, W., Pesonen, H., Ciroth, A., Brent, A. C., & Pagan, R. (2011). ***Environmental life-cycle costing : a code of practice.*** **Int J Life Cycle Assess,** *16*, 389–391. https://doi.org/10.1007/s11367-011-0287-5

- The World Bank. (2019). **Inflation, consumer prices (annual %). Retrieved** March 20, 2020, from

  https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG

- Thompson, S. K. (2012). **Sampling (3rd Editio)**. New York: John Wiley & Sons, Inc.

- U.S. Green Building Council (USGBC). (2011). **GREEN BUILDING AND LEED CORE CONCEPTS GUIDE (**second edi). Washington, DC: U.S. Green Building Council.

- W.BULL, J. (2014). **Life Cycle Cost for Construction**. London and Newyork: RoutledgeTaylor & Francis Group.

- Wang, J. C. (2016). **A study on the energy performance of school buildings in Taiwan.** Energy and Buildings, 133, 810–822. https://doi.org/https://doi.org/10.1016/j.enbuild.2016.10.036

- Wang, W., Zmeureanu, R., & Rivard, H. (2005). **Applying multi-objective genetic algorithms in green building design optimization.** Building and Environment, 40(11), 1512–1525. https://doi.org/10.1016/j.buildenv.2004.11.017

- Weiss, N. A. (2011). **Elementary Statistics** (8th-Editio ed.; D. Lynch, M. Stepanian, & S. J. Dill, Eds.). Arizona.

- Yaseen, E. B. (2007). **Renewable Energy Applications in Palestine**. In 2nd International Conference on the Palestinian Environment 2007 (Vol. 804).

- Yudelson, J. (2008). **The Green Building Revolution.** Washington: U.S. Green Building Council.

Appendixes

Appendixes A: Monthly Electricity Consumption Raw Data

A.1 Raw Data of the Monthly Electricity Consumption for Nablus Schools

Tables below represent the raw data of the monthly electricity consumption for each school that was selected from Nablus governorate as received from Northern Electricity Distribution company in Nablus city:

Table A.1: Energy consumption raw data for Fatimiya secondary school for girls.

Fatimiya secondary school for girls	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	650.00	650.00	800.00	974.00	798.00
February	964.00	1,038.00	837.00	1,843.00	1,027.00
March	822.00	898.00	493.00	576.00	1,314.00
April	1,378.00	1,244.00	1,562.00	1,440.00	944.00
May	1,227.00	1,051.00	841.00	1,047.00	1,043.00
June	918.00	608.00	621.00	661.00	298.00
July	568.00	503.00	375.00	401.00	564.00
August	403.00	238.00	471.00	445.00	619.00
September	1,115.00	1,124.00	1,101.00	1,054.00	844.00
October	1,387.00	1,343.00	944.00	1,139.00	1,484.00
November	926.00	1,517.00	1,601.00	1,494.00	1,409.00
December	1,180.00	932.00	1,503.00	1,222.00	1227
Total	11,538.00	11,146.00	11,149.00	12,296.00	11,571.00

Table A.2: Energy consumption raw data for Abn-Seena elementary girls school.

Abn-Seena elementary girls school	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	472.00	399.00	176.00	400.00	199.00
February	678.00	496.00	397.00	567.00	600.00
March	704.00	832.00	545.00	474.00	572.00
April	738.00	319.00	440.00	324.00	462.00
May	796.00	708.00	371.00	308.00	696.00
June	292.00	41.00	121.00	97.00	48.00

Table A.2 (*continued*)

July	503.00	52.00	123.00	163.00	153.00
August	670.00	162.00	363.00	292.00	112.00
September	1,100.00	606.00	447.00	321.00	630.00
October	565.00	1,239.00	701.00	851.00	868.00
November	665.00	536.00	540.00	439.00	642.00
December	374.00	409.00	470.00	476.00	619.00
Total	7,557.00	5,799.00	4,694.00	4,712.00	5,601.00

Table A.3: Energy consumption raw data for Al-itihad elementary boys school.

Al-itihad elementary boys school	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	114.00	93.00	221.00	284.00	500.00
February	159.00	217.00	221.00	332.00	484.00
March	360.00	510.00	106.00	527.00	562.00
April	521.00	320.00	447.00	351.00	530.00
May	287.00	260.00	377.00	437.00	475.00
June	218.00	143.00	187.00	182.00	45.00
July	163.00	124.00	114.00	235.00	29.00
August	182.00	183.00	373.00	190.00	206.00
September	250.00	149.00	90.00	342.00	251.00
October	160.00	427.00	307.00	318.00	521.00
November	464.00	342.00	308.00	543.00	386.00
December	333.00	419.00	382.00	465.00	560.00
Total	3,211.00	3,187.00	3,133.00	4,206.00	4,549.00

Table A.4: Energy consumption raw data for Imam Shafi'i elementary school for girls.

Imam Shafi'i elementary school for girls	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	263.00	369.00	346.00	388.00	570.00
February	204.00	231.00	363.00	430.00	504.00
March	252.00	311.00	390.00	730.00	616.00
April	358.00	413.00	400.00	492.00	346.00
May	335.00	469.00	410.00	248.00	324.00
June	315.00	239.00	273.00	167.00	112.00
July	135.00	143.00	287.00	93.00	128.00
August	65.00	275.00	245.00	340.00	120.00
September	290.00	320.00	405.00	260.00	110.00
October	536.00	445.00	360.00	280.00	315.00
November	299.00	370.00	412.00	300.00	245.00
December	390.00	371.00	420.00	230.00	215.00
Total	3,442.00	3,956.00	4,311.00	3,958.00	3,605.00

Table A.4 (*continued*)

Table A.5: Energy consumption raw data for Khansa elementary girls school.

Khansa elementary girls school	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	270.00	195.00	246.00	301.00	317.00
February	445.00	385.00	476.00	1,047.00	458.00
March	455.00	514.00	573.00	615.00	550.00
April	349.00	433.00	379.00	221.00	719.00
May	279.00	469.00	247.00	287.00	377.00
June	149.00	120.00	271.00	244.00	163.00
July	72.00	93.00	166.00	267.00	210.00
August	110.00	201.00	301.00	182.00	141.00
September	482.00	393.00	321.00	297.00	455.00
October	252.00	434.00	507.00	252.00	556.00
November	382.00	790.00	543.00	471.00	414.00
December	281.00	450.00	612.00	565.00	542.00
Total	3,526.00	4,477.00	4,642.00	4,749.00	4,902.00

Table A.6: Energy consumption raw data for Khadija om Al-Mouminine mixed elementary school.

Khadija om Al-Mouminine mixed elementary school	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	308.00	224.00	184.00	704.00	421.00
February	265.00	335.00	409.00	930.00	280.00
March	308.00	427.00	345.00	420.00	248.00
April	427.00	648.00	441.00	514.00	424.00
May	358.00	245.00	418.00	385.00	500.00
June	302.00	69.00	161.00	61.00	193.00
July	93.00	22.00	33.00	84.00	45.00
August	33.00	55.00	65.00	26.00	81.00
September	226.00	258.00	167.00	417.00	177.00
October	429.00	430.00	672.00	367.00	449.00
November	459.00	639.00	338.00	554.00	582.00
December	405.00	550.00	125.00	635.00	431.00
Total	3,613.00	3,902.00	3,358.00	5,097.00	3,831.00

Table A.7: Energy consumption raw data for Zeinabiyeh elementary boys school.

Zeinabiyeh elementary boys school	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	313.00	438.00	192.00	245.00	307.00
February	260.00	276.00	301.00	341.00	437.00
March	557.00	389.00	350.00	274.00	256.00
April	255.00	347.00	361.00	309.00	316.00
May	228.00	263.00	208.00	254.00	204.00
June	166.00	233.00	92.00	32.00	75.00
July	63.00	118.00	79.00	87.00	61.00
August	19.00	156.00	88.00	72.00	38.00
September	303.00	182.00	286.00	306.00	265.00
October	206.00	356.00	191.00	276.00	150.00
November	182.00	256.00	450.00	297.00	264.00
December	341.00	337.00	301.00	252.00	482.00
Total	2,893.00	3,351.00	2,899.00	2,745.00	2,855.00

Table A.8: Energy consumption raw data for Talouzeh Secondary mixed school.

Talouzeh secondary mixed school	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	198.00	559.00	431.00	815.00	296.00
February	274.00	673.00	964.00	1,030.00	918.00
March	519.00	611.00	296.00	709.00	1,014.00
April	432.00	1,015.00	840.00	673.00	845.00
May	306.00	379.00	736.00	490.00	513.00
June	154.00	591.00	132.00	194.00	192.00
July	63.00	133.00	78.00	78.00	210.00
August	131.00	113.00	1,088.00	819.00	214.00
September	230.00	1,654.00	547.00	935.00	966.00
October	926.00	524.00	713.00	479.00	900.00
November	688.00	917.00	967.00	1,438.00	860.00
December	694.00	1,021.00	549.00	775.00	130.00
Total	4,615.00	8,190.00	7,341.00	8,435.00	7,058.00

Table A.9: Energy consumption raw data for Samir Saad Eddin secondary school for girls.

Samir Saad Eddin secondary school for girls	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	688.00	1,365.00	479.00	479.00	2,053.00
February	1,131.00	1,317.00	1,261.00	1,261.00	1,240.00

Table A.9 (*continued*)

March	1,286.00	1,989.00	1,604.00	1,604.00	1,236.00
April	1,231.00	627.00	787.00	787.00	912.00
May	1,316.00	1,105.00	1,089.00	1,089.00	1,181.00
June	1,427.00	959.00	1,545.00	1,545.00	1,434.00
July	488.00	1,606.00	386.00	386.00	1,011.00
August	204.00	622.00	901.00	901.00	433.00
September	999.00	822.00	1,292.00	1,292.00	1,403.00
October	1,652.00	2,573.00	1,487.00	1,487.00	1,988.00
November	1,369.00	1,348.00	1,809.00	1,809.00	1,050.00
December	1,048.00	1,374.00	1,726.00	1,726.00	1,120.00
Total	12,839.00	15,707.00	14,366.00	14,366.00	15,061.00

Table A.10: Energy consumption raw data for Abdulmagith Al - Ansari elementary boys.

Abdulmagith Al - Ansari elementary boys	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	653.00	364.00	453.00	723.00	883.00
February	653.00	519.00	403.00	668.00	510.00
March	683.00	985.00	867.00	1,396.00	945.00
April	806.00	554.00	847.00	715.00	243.00
May	277.00	514.00	797.00	692.00	974.00
June	245.00	233.00	291.00	164.00	158.00
July	744.00	113.00	314.00	250.00	279.00
August	506.00	721.00	334.00	170.00	247.00
September	458.00	871.00	485.00	755.00	668.00
October	817.00	1,087.00	625.00	934.00	681.00
November	802.00	687.00	700.00	942.00	635.00
December	1,007.00	769.00	612.00	1,021.00	1,119.00
Total	7,651.00	7,417.00	6,728.00	8,430.00	7,342.00

Table A.11: Energy consumption raw data for IRAQ AL-Tayah secondary girls school.

IRAQ AL-Tayah secondary girls school	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	3,777.00	239.00	188.00	1,305.00	1,419.00
February	125.00	1,167.00	918.00	1,425.00	1,919.00
March	1,118.00	899.00	320.00	1,573.00	1,025.00
April	2,274.00	996.00	646.00	571.00	1,433.00
May	1,299.00	773.00	1,414.00	828.00	794.00
June	309.00	360.00	144.00	292.00	220.00
July	124.00	104.00	82.00	52.00	368.00

Table A.11 (*continued*)

August	178.00	145.00	788.00	455.00	413.00
September	1,305.00	353.00	753.00	985.00	1,444.00
October	1,457.00	1,619.00	1,802.00	1,404.00	635.00
November	1,361.00	1,278.00	782.00	1,129.00	1,357.00
December	762.00	1,086.00	691.00	1,065.00	1,497.00
Total	14,089.00	9,019.00	8,528.00	11,084.00	12,524.00

Table A.12: Energy consumption raw data for Kamal Jumblatt secondary school for girls.

Kamal Jumblatt secondary school for girls	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	457.00	163.00	301.00	308.00	178.00
February	685.00	408.00	126.00	498.00	827.00
March	610.00	499.00	667.00	721.00	413.00
April	1,015.00	582.00	420.00	529.00	510.00
May	616.00	294.00	105.00	407.00	440.00
June	167.00	178.00	25.00	504.00	40.00
July	21.00	8.00	50.00	100.00	21.00
August	31.00	138.00	243.00	40.00	129.00
September	479.00	670.00	182.00	38.00	501.00
October	137.00	533.00	765.00	722.00	802.00
November	494.00	488.00	295.00	425.00	693.00
December	552.00	281.00	263.00	543.00	591.00
Total	5,264.00	4,242.00	3,442.00	4,835.00	5,145.00

Table A.13: Energy consumption raw data for Azmout elementary girls school.

Azmout elementary girls school	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	133.00	104.00	13.00	262.00	262.00
February	203.00	199.00	334.00	439.00	439.00
March	184.00	241.00	445.00	486.00	486.00
April	246.00	286.00	326.00	340.00	340.00
May	250.00	162.00	70.00	314.00	314.00
June	108.00	154.00	8.00	235.00	235.00
July	22.00	41.00	52.00	97.00	97.00
August	0.00	134.00	269.00	123.00	123.00
September	23.00	558.00	205.00	134.00	134.00
October	7.00	383.00	551.00	481.00	481.00
November	208.00	360.00	145.00	417.00	417.00

Table A.13 (*continued*)

December	230.00	275.00	209.00	424.00	424.00
Total	1,614.00	2,897.00	2,627.00	3,752.00	3,752.00

Table A.14: Energy consumption raw data for Kamal Jumblatt secondary school for girls.

Kamal Jumblatt secondary school for girls	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	685.00	937.00	549.00	1,014.00	582.00
February	1,093.00	1,190.00	796.00	949.00	1,412.00
March	765.00	1,233.00	668.00	1,550.00	1,202.00
April	1,410.00	1,037.00	881.00	1,358.00	1,181.00
May	1,425.00	742.00	1,192.00	1,133.00	1,201.00
June	695.00	831.00	708.00	661.00	308.00
July	583.00	430.00	603.00	543.00	307.00
August	865.00	530.00	1,182.00	737.00	603.00
September	925.00	1,717.00	400.00	1,067.00	702.00
October	1,732.00	1,860.00	1,284.00	1,510.00	1,453.00
November	1,316.00	1,148.00	1,333.00	1,226.00	2,066.00
December	1,469.00	1,421.00	1,550.00	1,174.00	800.00
Total	12,963.00	13,076.00	11,146.00	12,922.00	11,817.00

Table A.15: Energy consumption raw data for Alnizamia (A) elementary school for girls.

Alnizamia (A) elementary school for girls	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	370.00	519.00	256.00	468.00	1,206.00
February	448.00	410.00	541.00	782.00	347.00
March	547.00	732.00	535.00	759.00	753.00
April	517.00	255.00	303.00	413.00	427.00
May	373.00	511.00	355.00	193.00	545.00
June	152.00	103.00	117.00	308.00	55.00
July	121.00	108.00	125.00	333.00	82.00
August	687.00	268.00	304.00	262.00	675.00
September	580.00	909.00	121.00	354.00	626.00
October	374.00	827.00	645.00	294.00	582.00
November	519.00	320.00	607.00	517.00	265.00
December	344.00	555.00	872.00	756.00	422.00
Total	5,032.00	5,517.00	4,781.00	5,439.00	5,985.00

Table A.16: Energy consumption raw data for Bassam Shakaa elementary school for Boys.

Bassam Shakaa elementary school for boys	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	786.00	421.00	729.00	664.00	1,896.00
February	118.00	1,175.00	901.00	1,275.00	403.00
March	49.00	918.00	1,143.00	1,182.00	1,570.00
April	1,728.00	1,389.00	1,290.00	1,409.00	1,441.00
May	725.00	740.00	606.00	1,035.00	1,376.00
June	325.00	253.00	252.00	740.00	1,137.00
July	279.00	19.00	142.00	296.00	399.00
August	310.00	141.00	95.00	255.00	283.00
September	555.00	709.00	698.00	2,409.00	572.00
October	1,076.00	1,380.00	1,729.00	1,618.00	1,805.00
November	1,015.00	1,513.00	1,193.00	558.00	1,673.00
December	704.00	1,437.00	1,864.00	727.00	1,174.00
Total	7,670.00	10,095.00	10,642.00	12,168.00	13,729.00

Table A.17: Energy consumption raw data for Zeinabia elementary school for girls.

Zeinabia elementary school for girls	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	174.00	193.00	218.00	526.00	190.00
February	164.00	313.00	362.00	326.00	640.00
March	486.00	308.00	246.00	344.00	646.00
April	222.00	327.00	217.00	302.00	456.00
May	269.00	264.00	301.00	243.00	253.00
June	222.00	168.00	50.00	148.00	134.00
July	176.00	56.00	5.00	48.00	61.00
August	130.00	71.00	5.00	49.00	0.00
September	267.00	281.00	229.00	203.00	148.00
October	227.00	361.00	206.00	233.00	247.00
November	170.00	278.00	354.00	177.00	555.00
December	350.00	352.00	519.00	280.00	1,380.00
Total	2,857.00	2,972.00	2,712.00	2,879.00	4,710.00

Table A.18: Energy consumption raw data for Ruhi Alhindi elementary boys school/Tel.

Ruhi Alhindi elementary boys school/Tel	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	266.00	351.00	399.00	604.00	295.00
February	241.00	260.00	445.00	272.00	662.00
March	414.00	485.00	288.00	563.00	709.00
April	521.00	533.00	721.00	501.00	557.00
May	436.00	467.00	413.00	498.00	544.00
June	123.00	102.00	56.00	124.00	195.00
July	15.00	9.00	125.00	1,054.00	180.00
August	7.00	39.00	105.00	172.00	443.00
September	420.00	464.00	182.00	295.00	584.00
October	421.00	438.00	842.00	215.00	638.00
November	336.00	478.00	552.00	311.00	743.00
December	546.00	580.00	623.00	519.00	807.00
Total	3,746.00	4,206.00	4,751.00	5,128.00	6,357.00

Table A.19: Energy consumption raw data for Muscat mixed secondary school / Bayt Iba.

Muscat mixed secondary school / Bayt Iba	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	808.00	311.00	729.00	943.00	1,376.00
February	507.00	1,040.00	642.00	1,990.00	1,122.00
March	834.00	1,100.00	300.00	1,148.00	1,032.00
April	1,083.00	1,519.00	1,052.00	1,290.00	1,286.00
May	1,063.00	724.00	1,158.00	1,552.00	902.00
June	248.00	507.00	343.00	158.00	615.00
July	425.00	231.00	386.00	118.00	820.00
August	684.00	494.00	184.00	822.00	463.00
September	930.00	787.00	805.00	1,553.00	1,374.00
October	1,516.00	1,102.00	1,643.00	1,608.00	1,356.00
November	749.00	1,214.00	1,000.00	1,219.00	1,490.00
December	974.00	553.00	806.00	1,644.00	1,618.00
Total	9,821.00	9,582.00	9,048.00	14,045.00	13,454.00

Table A.20: Energy consumption raw data for Fatimiya secondary school for girls.

Fatimiya secondary school for girls	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	650.00	650.00	800.00	974.00	798.00
February	964.00	1,038.00	837.00	1,843.00	1,027.00
March	822.00	898.00	493.00	576.00	1,314.00
April	1,378.00	1,244.00	1,562.00	1,440.00	944.00
May	1,227.00	1,051.00	841.00	1,047.00	1,043.00
June	918.00	608.00	621.00	661.00	298.00
July	568.00	503.00	375.00	401.00	564.00
August	403.00	238.00	471.00	445.00	619.00
September	1,115.00	1,124.00	1,101.00	1,054.00	844.00
October	1,387.00	1,343.00	944.00	1,139.00	1,484.00
November	926.00	1,517.00	1,601.00	1,494.00	1,409.00
December	1,180.00	932.00	1,503.00	1,222.00	1227
Total	11,538.00	11,146.00	11,149.00	12,296.00	11,571.00

Table A.21: Energy consumption raw data for Saad bin Abi Waqas elementary mixed school.

Saad bin Abi Waqas elementary mixed school	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	538.00	473.00	589.00	643.00	946.00
February	539.00	264.00	209.00	467.00	125.00
March	700.00	574.00	469.00	1,001.00	833.00
April	990.00	552.00	701.00	954.00	483.00
May	758.00	595.00	611.00	523.00	594.00
June	486.00	217.00	177.00	10,472.00	331.00
July	146.00	139.00	258.00	67.00	26.00
August	162.00	215.00	58.00	51.00	187.00
September	226.00	191.00	199.00	235.00	9,099.00
October	668.00	514.00	474.00	478.00	1,815.00
November	501.00	530.00	637.00	652.00	612.00
December	621.00	615.00	607.00	589.00	519.00
Total	6,335.00	4,879.00	4,989.00	16,132.00	15,570.00

Table A.21: Energy consumption raw data for Saeed Bin Amer secondary school for girls.

Saeed Bin Amer secondary school for girls	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	903.00	1,248.00	1,059.00	620.00	1,202.00
February	1,471.00	1,455.00	1,201.00	777.00	1,724.00
March	1,844.00	2,235.00	917.00	1,102.00	1,143.00
April	1,224.00	122.00	1,541.00	944.00	1,008.00
May	955.00	602.00	796.00	799.00	601.00
June	322.00	148.00	86.00	106.00	89.00
July	280.00	83.00	67.00	237.00	119.00
August	215.00	74.00	187.00	243.00	362.00
September	101.00	885.00	838.00	1,198.00	569.00
October	961.00	1,211.00	1,051.00	1,277.00	452.00
November	965.00	859.00	998.00	1,127.00	2,255.00
December	565.00	1,471.00	849.00	833.00	1,043.00
Total	9,806.00	10,393.00	9,590.00	9,263.00	10,567.00

Table A.22: Energy consumption raw data for Alnizamia (B) elementary school for girls.

Alnizamia (B) elementary school for girls	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	235.00	235.00	144.00	144.00	720.00
February	295.00	295.00	328.00	328.00	370.00
March	594.00	594.00	442.00	442.00	365.00
April	298.00	298.00	276.00	276.00	379.00
May	271.00	271.00	281.00	281.00	462.00
June	219.00	219.00	70.00	70.00	50.00
July	206.00	206.00	104.00	104.00	110.00
August	203.00	203.00	72.00	72.00	136.00
September	419.00	419.00	245.00	245.00	429.00
October	529.00	529.00	708.00	708.00	570.00
November	428.00	428.00	411.00	411.00	325.00
December	282.00	282.00	330.00	330.00	262.00
Total	3,979.00	3,979.00	3,411.00	3,411.00	4,178.00

Table A.23: Energy consumption raw data for Burhan Kamal elementary school for boys.

Burhan Kamal elementary school for boys	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	845.00	883.00	883.00	1,057.00	574.00
February	280.00	588.00	588.00	764.00	953.00
March	1,947.00	1,030.00	1,030.00	928.00	921.00
April	486.00	1,024.00	1,024.00	857.00	605.00
May	576.00	782.00	782.00	13.00	574.00
June	1,369.00	382.00	382.00	529.00	276.00
July	227.00	215.00	215.00	514.00	200.00
August	363.00	80.00	80.00	84.00	72.00
September	329.00	290.00	290.00	237.00	225.00
October	136.00	700.00	700.00	467.00	540.00
November	1,317.00	621.00	621.00	923.00	714.00
December	257.00	733.00	733.00	408.00	495.00
Total	8,132.00	7,328.00	7,328.00	6,781.00	6,149.00

Table A.24: Energy consumption raw data for Qusin secondary school for girls.

Qusin secondary school for girls	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	686.00	686.00	481.00	839.00	1,692.00
February	702.00	702.00	380.00	451.00	715.00
March	789.00	789.00	676.00	681.00	886.00
April	551.00	551.00	754.00	805.00	928.00
May	448.00	448.00	83.00	526.00	789.00
June	134.00	134.00	73.00	151.00	131.00
July	10.00	10.00	288.00	87.00	315.00
August	483.00	483.00	643.00	250.00	137.00
September	589.00	589.00	1,375.00	290.00	327.00
October	563.00	563.00	388.00	899.00	835.00
November	451.00	451.00	681.00	1,261.00	836.00
December	512.00	512.00	214.00	591.00	1,044.00
Total	5,918.00	5,918.00	6,036.00	6,831.00	8,635.00

Table A.25: Energy consumption raw data for Kfarqaleel secondary school for girls.

Kfarqaleel secondary school for girls	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	239.00	185.00	204.00	322.00	429.00
February	232.00	156.00	205.00	414.00	563.00
March	322.00	106.00	227.00	509.00	582.00
April	442.00	357.00	626.00	631.00	636.00
May	381.00	332.00	512.00	550.00	667.00
June	147.00	163.00	185.00	213.00	60.00
July	39.00	138.00	45.00	236.00	64.00
August	29.00	197.00	43.00	251.00	255.00
September	398.00	404.00	430.00	759.00	469.00
October	484.00	475.00	552.00	924.00	951.00
November	298.00	410.00	821.00	790.00	1,016.00
December	402.00	404.00	553.00	663.00	675.00
Total	3,413.00	3,327.00	4,403.00	6,262.00	6,367.00

Table A.26: Energy consumption raw data for Jamal Al - Masri elementary girls school.

Jamal Al - Masri elementary girls school	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	1,327.00	914.00	672.00	1,223.00	1,589.00
February	3,442.00	959.00	1,148.00	1,481.00	1,716.00
March	1,180.00	1,363.00	905.00	2,847.00	989.00
April	2,166.00	1,611.00	1,471.00	2,499.00	982.00
May	743.00	2,790.00	1,266.00	1,242.00	1,166.00
June	493.00	177.00	487.00	258.00	143.00
July	194.00	492.00	219.00	500.00	319.00
August	413.00	293.00	312.00	267.00	613.00
September	1,696.00	1,388.00	616.00	263.00	1,383.00
October	1,546.00	1,666.00	1,504.00	695.00	1,406.00
November	2,004.00	1,397.00	764.00	1,417.00	1,284.00
December	1,729.00	1,647.00	1,086.00	1,269.00	1,655.00
Total	16,933.00	14,697.00	10,450.00	13,961.00	13,245.00

Table A.27: Energy consumption raw data for Deir El-Hatab elementary school for boys/ Salem.

Deir El-Hatab elementary school for boys/ Salem	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	814.00	581.00	715.00	499.00	249.00
February	838.00	1,037.00	1,848.00	897.00	1,370.00
March	979.00	866.00	1,410.00	1,242.00	748.00
April	1,127.00	1,194.00	1,315.00	1,186.00	708.00
May	821.00	781.00	625.00	848.00	1,264.00
June	270.00	219.00	361.00	260.00	204.00
July	122.00	129.00	337.00	882.00	62.00
August	792.00	576.00	205.00	98.00	272.00
September	452.00	1,437.00	1,495.00	807.00	1,086.00
October	1,687.00	1,117.00	1,480.00	1,501.00	1,527.00
November	434.00	1,569.00	1,430.00	917.00	1,279.00
December	1,168.00	1,893.00	1,018.00	892.00	1,156.00
Total	9,504.00	11,399.00	12,239.00	10,029.00	9,925.00

Table A.28: Energy consumption raw data for Abdul Rahim Jardaneh secondary boys school.

Abdul Rahim Jardaneh secondary boys school	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	790.00	307.00	703.00	675.00	675.00
February	695.00	1,099.00	634.00	998.00	899.00
March	643.00	748.00	549.00	1,714.00	3,297.00
April	751.00	1,034.00	1,145.00	527.00	1,173.00
May	1,063.00	591.00	423.00	1,187.00	886.00
June	422.00	437.00	432.00	486.00	547.00
July	342.00	98.00	190.00	873.00	486.00
August	169.00	91.00	343.00	177.00	317.00
September	1,301.00	662.00	693.00	995.00	819.00
October	631.00	574.00	521.00	913.00	1,281.00
November	776.00	1,066.00	1,692.00	2,215.00	2,039.00
December	960.00	898.00	1,688.00	1,054.00	908.00
Total	8,543.00	7,605.00	9,013.00	11,814.00	13,327.00

Table A.29: Energy consumption raw data for Omar Al - Mukhtar elementary girls school.

Omar Al - Mukhtar elementary girls school	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	502.00	744.00	267.00	383.00	383.00
February	693.00	835.00	512.00	982.00	982.00
March	572.00	1,085.00	719.00	634.00	634.00
April	800.00	406.00	492.00	358.00	358.00
May	641.00	571.00	434.00	303.00	303.00
June	281.00	269.00	134.00	291.00	291.00
July	552.00	152.00	156.00	382.00	382.00
August	485.00	336.00	445.00	269.00	269.00
September	1,140.00	1,421.00	578.00	366.00	366.00
October	871.00	665.00	822.00	1,130.00	1,130.00
November	1,089.00	660.00	671.00	310.00	310.00
December	645.00	576.00	683.00	583.00	583.00
Total	8,271.00	7,720.00	5,913.00	5,991.00	5,991.00

Table A.30: Energy consumption raw data for Haj Mohammed Ali Qarman elementary school for boys.

Haj Mohammed Ali Qarman elementary school for boys.	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	851.00	1,801.00	1,426.00	2,005.00	2,303.00
February	1,113.00	756.00	1,580.00	2,050.00	2,951.00
March	1,089.00	1,679.00	2,138.00	2,462.00	2,924.00
April	1,633.00	1,681.00	666.00	2,228.00	1,991.00
May	1,284.00	1,376.00	1,573.00	1,628.00	1,911.00
June	562.00	449.00	488.00	907.00	494.00
July	95.00	267.00	500.00	515.00	74.00
August	278.00	252.00	255.00	513.00	766.00
September	1,063.00	1,246.00	1,075.00	1,427.00	1,539.00
October	2,058.00	1,424.00	1,317.00	1,603.00	2,019.00
November	591.00	1,341.00	1,761.00	2,963.00	1,664.00
December	1,737.00	2,049.00	2,106.00	1,697.00	2,096.00
Total	12,354.00	14,321.00	14,885.00	19,998.00	20,732.00

Table A.31: Energy consumption raw data for Yasid secondary school for girls.

Yasid secondary school for girls	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	159.00	216.00	162.00	419.00	378.00
February	360.00	175.00	295.00	320.00	532.00
March	177.00	524.00	576.00	778.00	624.00
April	566.00	376.00	437.00	398.00	672.00
May	234.00	223.00	178.00	158.00	348.00
June	217.00	77.00	52.00	156.00	216.00
July	114.00	3.00	0.00	260.00	52.00
August	60.00	147.00	229.00	177.00	325.00
September	242.00	434.00	404.00	193.00	303.00
October	329.00	464.00	430.00	1,141.00	636.00
November	374.00	482.00	344.00	544.00	626.00
December	315.00	358.00	359.00	415.00	721.00
Total	3,147.00	3,479.00	3,466.00	4,959.00	5,433.00

Table A.32: Energy consumption raw data for Yousef Al - Barqawi elementary boys school.

Yousef Al - Barqawi elementary boys school	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	369.00	547.00	628.00	664.00	707.00
February	190.00	267.00	289.00	486.00	794.00
March	369.00	501.00	446.00	817.00	908.00
April	588.00	687.00	522.00	678.00	645.00
May	510.00	562.00	492.00	564.00	748.00
June	418.00	356.00	128.00	403.00	158.00
July	168.00	133.00	194.00	68.00	64.00
August	202.00	130.00	202.00	328.00	677.00
September	266.00	307.00	202.00	210.00	343.00
October	531.00	439.00	468.00	404.00	437.00
November	347.00	363.00	498.00	601.00	757.00
December	605.00	660.00	582.00	603.00	741.00
Total	4,563.00	4,952.00	4,651.00	5,826.00	6,979.00

Table A.33: Energy consumption raw data for Zafer Al Masri secondary school for girls.

Zafer Al Masri secondary school for girls	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	953.00	1,485.00	922.00	922.00	1,003.00
February	1,172.00	707.00	859.00	859.00	1,430.00
March	953.00	1,355.00	774.00	774.00	1,647.00
April	1,259.00	1,379.00	1,273.00	1,273.00	1,441.00
May	1,063.00	1,263.00	1,257.00	1,257.00	1,457.00
June	800.00	794.00	644.00	644.00	888.00
July	410.00	529.00	630.00	630.00	321.00
August	287.00	476.00	548.00	548.00	611.00
September	1,009.00	900.00	657.00	657.00	1,183.00
October	1,303.00	1,447.00	1,104.00	1,104.00	1,706.00
November	967.00	1,120.00	1,049.00	1,049.00	1,651.00
December	1,385.00	1,250.00	1,351.00	1,351.00	1,739.00
Total	11,561.00	12,705.00	11,068.00	11,068.00	15,077.00

Table A.34: Energy consumption raw data for Mohammed bin Rashid Al Maktoum elementary boys school.

Mohammed bin Rashid Al Maktoum elementary boys school	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	264.00	435.00	417.00	783.00	167.00
February	295.00	228.00	355.00	118.00	746.00
March	376.00	520.00	425.00	548.00	694.00
April	437.00	571.00	840.00	563.00	480.00
May	510.00	566.00	565.00	525.00	539.00
June	218.00	38.00	463.00	225.00	132.00
July	45.00	147.00	22.00	137.00	163.00
August	63.00	165.00	33.00	257.00	384.00
September	360.00	580.00	579.00	675.00	554.00
October	561.00	550.00	665.00	491.00	717.00
November	450.00	766.00	633.00	714.00	753.00
December	666.00	727.00	684.00	469.00	583.00
Total	4,245.00	5,293.00	5,681.00	5,505.00	5,912.00

Table A.35: Energy consumption raw data for Yasser Arafat secondary girls school.

Yasser Arafat secondary girls school	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	1,064.00	1,451.00	1,815.00	1,571.00	1,417.00
February	729.00	958.00	808.00	906.00	1,751.00
March	1,512.00	2,086.00	1,269.00	1,796.00	1,720.00
April	1,641.00	1,364.00	1,740.00	1,982.00	1,578.00
May	1,487.00	1,776.00	1,662.00	1,258.00	797.00
June	1,309.00	1,170.00	1,184.00	1,110.00	1,117.00
July	760.00	332.00	384.00	176.00	555.00
August	95.00	267.00	1,530.00	267.00	480.00
September	878.00	693.00	751.00	944.00	2,566.00
October	1,916.00	1,814.00	1,650.00	1,566.00	1,524.00
November	1,082.00	1,774.00	1,993.00	2,186.00	1,824.00
December	1,784.00	1,963.00	1,857.00	2,029.00	1,698.00
Total	14,257.00	15,648.00	16,643.00	15,791.00	17,027.00

Table A.36: Energy consumption raw data for Aisha secondary school for girls.

Aisha secondary school for girls	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	567.00	816.00	816.00	693.00	1,653.00
February	852.00	849.00	849.00	1,224.00	990.00
March	927.00	1,129.00	1,129.00	409.00	983.00
April	894.00	419.00	419.00	771.00	890.00
May	1,017.00	699.00	699.00	778.00	904.00
June	258.00	407.00	407.00	685.00	551.00
July	49.00	450.00	450.00	503.00	800.00
August	147.00	405.00	405.00	486.00	503.00
September	793.00	423.00	423.00	629.00	539.00
October	995.00	2,111.00	2,111.00	2,353.00	2,952.00
November	903.00	1,058.00	1,058.00	971.00	896.00
December	748.00	1,173.00	1,173.00	944.00	940.00
Total	8,150.00	9,939.00	9,939.00	10,446.00	12,601.00

Table A.37: Energy consumption raw data for Carmel secondary school for girls.

Carmel secondary school for girls	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	509.00	268.00	364.00	711.00	793.00
February	387.00	599.00	546.00	822.00	728.00
March	515.00	581.00	246.00	648.00	1,045.00
April	755.00	610.00	741.00	749.00	757.00
May	249.00	756.00	581.00	619.00	766.00
June	280.00	69.00	79.00	221.00	129.00
July	21.00	155.00	56.00	277.00	225.00
August	25.00	40.00	44.00	259.00	227.00
September	338.00	540.00	368.00	535.00	641.00
October	576.00	679.00	557.00	816.00	991.00
November	537.00	562.00	799.00	777.00	821.00
December	685.00	768.00	550.00	1,201.00	902.00
Total	4,877.00	5,627.00	4,931.00	7,635.00	8,025.00

A.2 Raw Data of the Monthly Electricity Consumption for Jenin Schools

Tables below represent the raw data of the monthly electricity consumption for each school that was selected from Jenin governorate as received from Northern Electricity Distribution company in Nablus city:

Table A.38: Energy consumption raw data for Alshahida Muntaha Hourani elementary school for girls.

Alshahida Muntaha Hourani elementary school for girls	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	0	198	414	414	885
February	298	583	353	353	717
March	127	425	1,066	1,066	526
April	250	518	808	808	663
May	148	299	500	500	67
June	0	0	147	147	134
July	47	327	30	30	106
August	216	316	0	0	302
September	419	661	819	819	642
October	483	1,107	732	732	682
November	511	978	840	840	483
December	393	655	792	792	853
Total	2,892	6,067	6,501	6,501	6,060

Table A.39: Energy consumption raw data for Jenin secondary school for boys.

Jenin secondary school for boys	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	670	1,522	1,031	862	852
February	1,433	1,079	275	1,902	1436
March	1,333	932	1,384	1,004	1301
April	1,002	1,300	856	1,139	1069
May	812	745	91	799	639
June	0	303	937	406	94
July	0	248	630	532	800
August	1,248	941	1,139	1,255	2033
September	1,768	1,374	794	1,588	1662
October	974	1,975	2,054	1,505	2028

Table A.39 (continued)

November	1,318	1,135	1,707	1,726	720
December	321	1,027	1,018	706	1164
Total	10,879	12,581	11,916	13,424	13,798

Table A.40: Energy consumption raw data for Yamoun secondary school for boys.

Yamoun secondary school for boys	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	1,100	1,625	1,464	465	2,838
February	1,800	2,339	2,012	2,948	1,561
March	1,518	1,514	1,892	2,107	1,596
April	1,482	1,655	1,550	1,063	1,378
May	1,600	0	189	78	211
June	0	0	21	52	100
July	0	1,024	3,015	32	60
August	1,928	1,313	1,271	2,752	4,224
September	2,123	2,376	1,981	1,620	2,800
October	2,001	2,754	1,778	2,038	2,456
November	7,714	2,337	2,247	1,583	1,619
December	1,461	2,376	1,787	331	1,188
Total	22,727	19,313	19,207	15,069	20,031

Table A.41: Energy consumption raw data for Nusseibeh Almaznieh elementary school for girls.

Nusseibeh Almaznieh elementary school for girls	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	450.00	855.00	1,726.00	1,240.00	0.00
February	1,145.00	1,142.00	867.00	1,523.00	0.00
March	1,519.00	1,056.00	1,381.00	1,210.00	637.00
April	1,413.00	1,305.00	1,275.00	958.00	865.00
May	404.00	802.00	782.00	910.00	34.00
June	0.00	0.00	19.00	48.00	100.00
July	0.00	355.00	283.00	39.00	588.00
August	1,309.00	1,073.00	884.00	1,315.00	669.00
September	1,144.00	1,350.00	1,453.00	1,083.00	1,060.00
October	1,452.00	1,736.00	1,218.00	1,330.00	1,287.00
November	1,166.00	1,435.00	1,413.00	1,089.00	975.00
December	647.00	146.00	1,394.00	856.00	482.00
Total	10,649.00	11,255.00	12,695.00	11,601.00	6,697.00

Table A.42: Energy consumption raw data for Alshahid Salah Khalaf elementary school for boys.

Alshahid Salah Khalaf elementary school for boys	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	70	86	223	354	528
February	112	168	155	400	348
March	100	133	200	300	323
April	150	147	187	99	345
May	100	0	22	88	88
June	0	0	23	33	90
July	0	234	82	22	14
August	0	96	367	459	341
September	152	256	280	571	670
October	148	234	299	531	589
November	0	205	366	323	428
December	0	199	433	392	426
Total	832	1,758	2,637	3,572	4,190

Table A.43: Energy consumption raw data for Jenin Industrial secondary school.

Jenin Industrial secondary school	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	3,000	3,298	2884	3,279	3,279
February	4,424	3,812	3403	4,776	4,776
March	4,337	4,179	4843	4,442	4,442
April	4,024	2,915	3169	3,326	3,326
May	1,018	1,931	1866	2,083	2,083
June	2,176	3,465	767	600	600
July	1,113	479	521	778	778
August	4,400	6,105	4265	5,099	5,099
September	5,263	1,799	1874	3,414	3,414
October	3,343	3,782	4539	4,684	4,684
November	4,809	3,290	5034	7,228	7,228
December	3,142	5,112	4341	1,791	1,791
Total	41,049	40,167	37,506	41,500	41,500

Table A.44: Energy consumption raw data for Hitteen secondary school for boys.

Hitteen secondary school for boys	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	736.00	728.00	661.00	940.00	1,177.00
February	1,128.00	993.00	442.00	1,114.00	998.00

Table A.44 (continued)

March	1,384.00	735.00	796.00	756.00	944.00
April	1,003.00	712.00	945.00	758.00	1,063.00
May	415.00	602.00	579.00	1,060.00	1,110.00
June	0.00	310.00	457.00	187.00	273.00
July	1,545.00	346.00	450.00	619.00	637.00
August	708.00	1,169.00	987.00	1,216.00	1,453.00
September	1,018.00	581.00	1,167.00	1,929.00	1,921.00
October	890.00	811.00	626.00	1,629.00	1,515.00
November	928.00	788.00	1,126.00	1,322.00	820.00
December	825.00	984.00	601.00	1,173.00	848.00
Total	10,580.00	8,759.00	8,837.00	12,703.00	12,759.00

Table A.45: Energy consumption raw data for Hitteen elementary school for boys.

Hitteen elementary school for boys	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	827	764	639	1,050	1,004
February	1,253	1,919	483	1,240	1,295
March	1,189	13	1,483	989	1,306
April	994	1,412	1,171	1,320	1,245
May	854	985	103	1,010	1,180
June	0	0	1,133	385	190
July	529	575	216	823	55
August	471	690	1,031	952	1,893
September	1,573	1,353	1,266	1,534	1,461
October	926	1,350	884	1,195	1,228
November	1,032	1,123	1,046	1,345	1,012
December	1,261	1,523	1,050	881	1,027
Total	10,909	11,707	10,505	12,724	12,896

Table A.46: Energy consumption raw data for Qasem Mohammed Qasem elementary mixed school.

Qasem Mohammed Qasem elementary mixed school	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	0.000	0.000	438.00	644.00	891.00
February	0.000	0.000	495.00	1,152.00	746.00
March	0.000	0.000	774.00	985.00	808.00
April	0.000	0.000	856.00	1,201.00	1,203.00
May	0.000	0.000	400.00	186.00	92.00

Table A.46 (continued)

June	0.000	0.000	99.00	402.00	253.00
July	0.000	0.000	206.00	446.00	229.00
August	0.000	1,011.00	991.00	812.00	679.00
September	0.000	388.00	384.00	640.00	1,169.00
October	0.000	645.00	1,064.00	924.00	1,764.00
November	0.000	741.00	1,255.00	1,546.00	450.00
December	0.000	741.00	971.00	362.00	779.00
Total	0.000	3,526.00	7,933.00	9,300.00	9,063.00

Table A.47: Energy consumption raw data for Al-Salam secondary school for boys.

Al-Salam secondary school for boys	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	1,085	966	718	1,054	864
February	1,502	1,332	830	1,180	1,158
March	1,493	978	1,158	860	1,048
April	1,432	911	1,284	969	1,409
May	707	909	922	1,721	1,500
June	0	431	553	648	308
July	1,483	510	509	1,139	707
August	1,832	1,980	1,138	1,466	1,739
September	1,812	1,238	1,202	2,041	2,631
October	1,032	1,585	1,400	1,933	1,996
November	1,194	1,219	1,630	1,354	890
December	1,084	1,518	741	968	1,023
Total	14,656	13,577	12,085	15,333	15,273

Table A.48: Energy consumption raw data for Alshahida Kadoura Moussa elementary school for girls.

Alshahida Kadoura Moussa elementary school for girls	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	357	581	741	886	980
February	791	1,244	507	1,361	1,258
March	583	868	1,036	884	894
April	1,400	847	968	1,077	1,411
May	398	546	546	1,066	747
June	0	13	206	155	30
July	170	31	506	260	210
August	612	854	665	667	669
September	1,073	526	1,435	1,027	1,394
October	798	871	724	1,140	1,429

Table A.48 (*continued*)

November	966	999	1,430	1,191	855
December	445	1,096	960	883	1,241
Total	7,593	8,476	9,724	10,597	11,118

Table A.49: Energy consumption raw data for Al-Malaysia elementary school for girls.

Al-Malaysia elementary school for girls	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	475	907	1,019	1,091	1,091
February	1,117	1,142	661	1,467	1,467
March	1,399	1,678	1,236	1,551	1,551
April	1,240	1,346	1,595	1,433	1,433
May	628	0	893	1,090	1,090
June	0	0	18	125	125
July	0	1,050	197	98	98
August	1,389	2,451	1,755	1,120	1,120
September	2,402	1,498	772	1,829	1,829
October	1,688	2,022	1,969	2,175	2,175
November	2,037	1,192	1,823	1,545	1,545
December	734	830	1,426	1,035	1,035
Total	13,109	14,116	13,364	14,559	14,559

Table A.50: Energy consumption raw data for Amna Bint Wahab school for girls.

Amna Bint Wahab school for girls	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	0	0	0	914	1,698
February	0	0	0	1,455	1,321
March	0	0	0	1,801	1,668
April	0	0	0	1,316	1,509
May	0	0	0	93	90
June	0	0	0	25	80
July	0	0	0	22	1,425
August	0	0	783	2,194	816
September	0	0	1,790	967	1,897
October	0	0	1,584	1,820	1,882
November	0	0	1,741	1,363	1,487
December	0	0	1,153	548	855
Total	0	0	7,051	12,518	14,728

Table A.51: Energy consumption raw data for Bilal Al - Awsat elementary boys school.

Bilal Al - Awsat elementary boys school	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	841	754	1,224	2,460	3,837
February	1,522	1,459	950	4,099	2,232
March	1,557	1,105	1,213	2,334	2,125
April	1,392	1,105	1,037	1,121	2,017
May	635	0	62	108	74
June	0	0	13	45	100
July	0	878	43	55	80
August	1,223	975	1,589	3,204	1,481
September	1,435	1,273	1,494	2,167	974
October	1,307	1,193	1,120	2,503	1,821
November	1,275	1,106	1,423	2,106	3,135
December	652	1,361	1,632	840	1,978
Total	11,839	11,209	11,800	21,042	19,854

Table A.52: Energy consumption raw data for Palestinian - Turkish Friendship girls school.

Palestinian - Turkish Friendship girls school	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	290	658	308	850	810
February	825	636	482	1,203	1,587
March	910	455	693	918	1,644
April	635	692	714	736	388
May	423	0	665	81	91
June	0	0	21	48	309
July	0	381	93	52	91
August	1,119	587	419	1,155	511
September	849	777	261	1,217	3,038
October	958	1,408	1,121	1,548	144
November	947	414	871	1,380	1,377
December	243	592	964	968	1,503
Total	7,199	6,600	6,612	10,156	11,493

Table A.53: Energy consumption raw data for Al - Ibrahimin secondary girls school.

Al - Ibrahimin secondary girls school	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	802	991	1,244	1,094	1,427
February	1,575	1,633	1,485	2,162	1,821
March	1,552	1,439	1,516	1,274	1,165
April	1,015	1,241	835	699	1,111
May	557	969	303	687	428
June	0	547	105	21	104
July	394	191	34	6	141
August	1,303	1,826	606	454	1,174
September	1,530	729	714	1,152	1,390
October	1,284	1,128	506	774	714
November	1,147	1,212	603	407	815
December	789	1,814	1,231	1,072	1,934
Total	11,948	13,720	9,182	9,802	12,224

Table A.54: Energy consumption raw data for Walid Abu Mowais elementary girls school.

Walid Abu Mowais elementary girls school	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	858	942	1,172	2,119	1,852
February	1,320	1,425	516	651	2,105
March	1,586	1,415	895	1,796	1,325
April	1,881	706	1,600	1,409	1,605
May	263	0	59	646	784
June	0	0	25	86	132
July	0	913	396	420	951
August	1,149	937	1,145	1,046	537
September	1,512	1,186	1,777	1,570	1,570
October	1,800	1,417	1,395	1,260	1,639
November	1,441	1,519	1,486	1,757	2,129
December	1,138	696	882	1,184	1,226
Total	12,948	11,156	11,348	13,944	15,855

Table A.55: Energy consumption raw data for Al-Salhin elementary boys school.

Al-Salhin elementary boys school	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	634.00	838.00	838.00	785.00	1,745.00
February	1,207.00	1,313.00	1,313.00	1,394.00	1,105.00
March	1,368.00	3,500.00	3,500.00	1,245.00	1,314.00
April	1,246.00	0.00	0.00	780.00	724.00
May	485.00	0.00	0.00	55.00	98.00
June	0.00	0.00	0.00	43.00	100.00
July	0.00	0.00	0.00	33.00	80.00
August	1,137.00	142.00	142.00	1,530.00	2,357.00
September	1,206.00	1,083.00	1,083.00	874.00	1,893.00
October	1,366.00	1,229.00	1,229.00	1,771.00	1,519.00
November	1,277.00	1,249.00	1,249.00	1,193.00	1,040.00
December	667.00	967.00	967.00	525.00	765.00
Total	10,593.00	10,321.00	10,321.00	10,228.00	12,740.00

Table A.56: Energy consumption raw data for Mohammad Arshid Yassin elementary boys school.

Mohammad Arshid Yassin elementary boys school	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	303.00	444.00	588.00	588.00	964.00
February	400.00	570.00	282.00	282.00	566.00
March	521.00	584.00	528.00	528.00	667.00
April	457.00	297.00	632.00	632.00	680.00
May	162.00	0.00	36.00	36.00	61.00
June	0.00	0.00	240.00	240.00	52.00
July	250.00	346.00	30.00	30.00	227.00
August	433.00	375.00	406.00	406.00	657.00
September	506.00	498.00	490.00	490.00	879.00
October	444.00	584.00	712.00	712.00	749.00
November	634.00	553.00	1,049.00	1,049.00	661.00
December	352.00	274.00	549.00	549.00	75.00
Total	4,462.00	4,525.00	5,542.00	5,542.00	6,238.00

Table A.57: Energy consumption raw data for Anin elementary girls school.

Anin elementary girls school	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	329.00	329.00	329.00	358.00	690.00
February	420.00	420.00	420.00	582.00	502.00
March	464.00	464.00	464.00	639.00	279.00
April	402.00	402.00	402.00	444.00	593.00
May	135.00	135.00	135.00	82.00	74.00
June	0.00	0.00	0.00	31.00	72.00
July	0.00	0.00	0.00	62.00	204.00
August	399.00	399.00	399.00	631.00	399.00
September	248.00	248.00	248.00	503.00	562.00
October	531.00	531.00	531.00	668.00	619.00
November	388.00	388.00	388.00	438.00	496.00
December	204.00	204.00	204.00	290.00	98.00
Total	3,520.00	3,520.00	3,520.00	4,728.00	4,588.00

Table A.58: Energy consumption raw data for Kfardan elementary girls school.

Kfardan elementary girls school	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	857.00	1,032.00	1,111.00	1,353.00	2,126.00
February	1,407.00	1,755.00	818.00	1,953.00	2,286.00
March	1,961.00	1,314.00	1,607.00	1,644.00	1,977.00
April	1,735.00	1,492.00	1,425.00	853.00	1,383.00
May	483.00	627.00	48.00	74.00	235.00
June	0.00	19.00	14.00	37.00	163.00
July	0.00	68.00	68.00	27.00	207.00
August	1,326.00	1,131.00	1,279.00	2,354.00	1,520.00
September	1,783.00	1,432.00	1,312.00	1,212.00	2,623.00
October	1,642.00	1,473.00	1,262.00	2,192.00	2,647.00
November	1,712.00	1,587.00	1,754.00	1,708.00	2,374.00
December	795.00	1,292.00	1,454.00	886.00	1,942.00
Total	13,701.00	13,222.00	12,152.00	14,293.00	19,483.00

Table A.59: Energy consumption raw data for Sumaya Bint Al Khayat elementary girls school (Al Yamoun).

Sumaya Bint Al Khayat elementary girls school (Al Yamoun).	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	1,580.00	1,121.00	2,186.00	1,075.00	1,896.00
February	1,666.00	1,959.00	721.00	1,963.00	1,247.00
March	1,764.00	1,731.00	2,067.00	1,391.00	1,699.00
April	1,616.00	1,710.00	1,412.00	876.00	1,307.00
May	610.00	0.00	114.00	64.00	86.00
June	0.00	0.00	33.00	55.00	37.00
July	0.00	188.00	64.00	31.00	33.00
August	1,174.00	2,142.00	1,348.00	1,391.00	986.00
September	1,591.00	1,884.00	1,781.00	1,441.00	1,931.00
October	1,944.00	1,996.00	1,759.00	1,893.00	1,683.00
November	1,611.00	1,972.00	2,093.00	1,388.00	1,767.00
December	838.00	203.00	1,453.00	401.00	113.00
Total	14,394.00	14,906.00	15,031.00	11,969.00	12,785.00

Table A.60: Energy consumption raw data for Kafr Dan elementary school for boys.

Kafr Dan elementary school for boys	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	333.00	333.00	304.00	537.00	66.00
February	594.00	594.00	323.00	577.00	581.00
March	740.00	740.00	497.00	521.00	523.00
April	527.00	527.00	462.00	318.00	415.00
May	181.00	181.00	27.00	64.00	96.00
June	0.00	0.00	20.00	55.00	94.00
July	0.00	0.00	102.00	32.00	60.00
August	679.00	679.00	322.00	814.00	490.00
September	386.00	386.00	504.00	446.00	645.00
October	375.00	375.00	447.00	551.00	744.00
November	416.00	416.00	511.00	891.00	691.00
December	74.00	74.00	484.00	521.00	280.00
Total	4,305.00	4,305.00	4,003.00	5,327.00	4,685.00

Table A.61: Energy consumption raw data for Anin secondary school for boys.

Anin secondary school for boys	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	490	627	764	556	861
February	638	761	337	759	585
March	825	728	633	783	662
April	1,080	395	758	460	523
May	347	188	27	88	106
June	0	0	432	47	51
July	1,989	137	32	55	99
August	528	521	501	769	1,105
September	775	624	558	716	1,068
October	698	740	759	889	1,155
November	860	760	985	623	912
December	378	369	622	241	105
Total	8,608	5,850	6,408	5,986	7,232

Table A.62: Energy consumption raw data for Banat Shuhadaa Al-Yamoun elementary school for girls.

for Banat Shuhadaa Al-Yamoun elementary school for girls	**Quantity (kWh)**				
Month/Year	2014	2015	2016	2017	2018
January	1,580	1,121	2,186	1,075	1,896
February	1,666	1,959	721	1,963	1,247
March	1,764	1,731	2,067	1,391	1,699
April	1,616	1,710	1,412	876	1,307
May	610	0	114	64	86
June	0	0	33	55	37
July	0	188	64	31	33
August	1,174	2,142	1,348	1,391	986
September	1,591	1,884	1,781	1,441	1,931
October	1,944	1,996	1,759	1,893	1,683
November	1,611	1,972	2,093	1,388	1,767
December	838	203	1,453	401	113
Total	14,394	14,906	15,031	11,969	12,785

Table A.63: Energy consumption raw data for Al - Zahraa secondary school for girls.

Al - Zahraa secondary school for girls.	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	582	546	1,528	1,596	2,342
February	1,136	1,488	606	2,058	2,105
March	1,272	1,417	1,328	1,463	1,200
April	1,004	1,371	1,230	1,380	1,221
May	535	829	856	1,142	0
June	0	227	396	740	1,631
July	954	104	316	399	1,168
August	1,167	1,417	1,156	1,332	934
September	2,467	1,975	2,122	1,838	1,890
October	1,198	1,768	1,596	1,646	2,315
November	1,756	1,733	1,798	1,882	1,367
December	1,388	684	1,463	1,392	1,757
Total	13,459	13,559	14,395	16,868	17,930

Table A.64: Energy consumption raw data for Haifa elementary school for girls.

Haifa elementary school for girls	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	266	298	256	449	571
February	505	487	459	825	821
March	692	374	611	575	694
April	608	399	529	554	742
May	351	290	349	578	349
June	0	110	13	12	27
July	222	48	95	45	38
August	328	584	339	358	486
September	522	317	380	716	1,149
October	373	473	682	850	910
November	477	413	655	863	516
December	361	639	421	757	941
Total	4,705	4,432	4,789	6,582	7,244

Table A.65: Energy consumption raw data for Yamoun secondary school for girls.

Yamoun secondary school for girls	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	1,120	1,868	2,688	1,009	3,062
February	1,606	2,146	951	2,141	1,682
March	1,751	1,419	1,603	1,597	1,660
April	1,578	1,470	1,212	1,012	1,414
May	628	931	39	74	70
June	0	262	17	54	100
July	0	161	90	25	60
August	1,877	1,283	1,813	2,424	2,088
September	1,842	1,742	1,635	1,614	2,338
October	1,949	1,825	1,357	2,212	1,826
November	1,533	1,594	1,678	1,426	1,083
December	524	203	1,382	741	1,425
Total	14,408	14,904	14,465	14,329	16,808

Table A.66: Energy consumption raw data for Malaysian Friendship secondary school for girls.

Malaysian Friendship secondary school for girls	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	475	907	1,019	1,091	1,091
February	1,117	1,142	661	1,467	1,467
March	1,399	1,678	1,236	1,551	1,551
April	1,240	1,346	1,595	1,433	1,433
May	628	0	893	1,090	1,090
June	0	0	18	125	125
July	0	1,050	197	98	98
August	1,389	2,451	1,755	1,120	1,120
September	2,402	1,498	772	1,829	1,829
October	1,688	2,022	1,969	2,175	2,175
November	2,037	1,192	1,823	1,545	1,545
December	734	830	1,426	1,035	1,035
Total	13,109	14,116	13,364	14,559	14,559

Table A.67: Energy consumption raw data for Al-Zahra elementary girls school.

Al-Zahra elementary girls school	Quantity (kWh)				
Month/Year	2014	2015	2016	2017	2018
January	1,283	2,079	2,190	1,765	1,725
February	1,963	2,746	1,072	2,687	2,463
March	1,975	2,519	2,243	1,898	2,153
April	1,462	2,436	1,996	1,952	2,610
May	97	0	1,067	62	1,249
June	0	0	409	1,839	169
July	1,840	1,530	656	65	1,058
August	1,216	1,979	1,006	1,910	1,446
September	2,430	2,888	2,594	3,009	2,894
October	2,588	2,460	2,211	2,978	4,178
November	2,459	2,736	2,691	2,951	2,171
December	1,670	1,026	2,426	2,133	2,480
Total	18,983	22,399	20,561	23,249	24,596

A.3 Raw Data of Both Energy Consumption Meter and Net Energy Generation Meter of the PV-system of Aqqaba Green School

Table A.68 below represents the raw data of both energy consumption meter and net energy generation meter of the PV-system of Aqqaba green school as received from the Municipality of Tubas city:

Table A.68: The raw data of both energy consumption meter and net energy generation meter of the PV-system of Aqqaba green school.

Reading date	**Net energy exported to the grid (kWh)**			**Energy consumption according to electricity bills (kWh)**		
	Previous	**Recent**	**Total**	**Previous**	**Recent**	**Total**
11/2/2016	4432	0	4432	6892	0	6892
1/12/2016	4867	4432	435	7446	6892	554
29/1/2017	6016	4867	1149	8302	7446	856
26/2/2017	7026	6016	1010	8958	8302	656
28/3/2017	8088	7026	1062	9661	8958	703
Total			8088			9661
27/4/2017	9612	8088	1524	10387	9661	726
29/5/2017	11123	9612	1511	11245	10387	858
1/7/2017	12311	11123	1188	11805	11245	560
7/31/2017	14550	12311	2239	12591	11805	786
8/27/2017	16140	14550	1590	13300	12591	709
27/9/2017	16863	16140	723	15066	13300	1766

Table A.85 (continued)

Reading date	Net energy exported to the grid (kWh)			Energy consumption according to electricity bills (kWh)		
	Previous	**Recent**	**Total**	**Previous**	**Recent**	**Total**
29/10/2017	17807	16863	944	16315	15066	1249
28/12/2017	19177	17807	1370	18032	16315	1717
1/28/2018	19870	19177	693	18412	18032	380
28/2/2018	20404	19870	534	19236	18412	824
28/3/2018	20969	20404	565	19960	19236	724
Total			12881			10299
2/5/2018	22754	20969	1785	20572	19960	612
31/5/2018	24282	22754	1528	20970	20572	398
8/7/2018	28855	24282	4573	21474	20970	504
4/9/2018	29781	28855	926	22195	21474	721
27/9/2018	30299	29781	518	23560	22195	1365
27/10/2018	30820	30299	521	25108	23560	1548
30/11/2018	30820	30820	0	25108	25108	0
30/12/2018	30820	30820	0	25108	25108	0
31/1/2019	32489	30820	1669	26848	25108	1740
28/2/2019	33055	32489	566	27475	26848	627
31/3/2019	33820	33055	765	28143	27475	668
Total			12851			8183
31/3/2019	34879	33820	1059	28824	28143	681
31/5/2019	36256	34879	1377	29276	28824	452
Total			1377			452

Appendixes B

B.1 Energy Life Cycle Cost Estimation for Public Schools in West Bank/Palestine

The energy life cycle cost analysis for public schools in West Bank/Palestine using different energy inflation rates are illustrated in the following tables:

Table B.1: Total estimated energy LCC for public schools in West Bank/Palestine with (-2%) energy inflation rate.

Total energy life cycle budget for public schools in West Bank/ Palestine (ILS), with -2% energy inflation rate						
Year	2019	2020	2021	2022	2023	2024
Inflated annual energy cost	6,531.61	6,400.98	6,272.96	6,147.50	6,024.55	5,904.06
Cumulative energy cost	6,531.61	12,932.59	19,205.55	25,353.05	31,377.59	37,281.65
Year	2025	2026	2027	2028	2029	2030
Inflated annual energy cost	5,785.98	5,670.26	5,556.85	5,445.72	5,336.80	5,230.06
Cumulative energy cost	43,067.63	48,737.89	54,294.74	59,740.45	65,077.26	70,307.32
Year	2031	2032	2033	2034	2035	2036
Inflated annual energy cost	5,125.46	5,022.95	4,922.50	4,824.05	4,727.56	4,633.01
Cumulative energy cost	75,432.78	80,455.74	85,378.23	90,202.28	94,929.84	99,562.86
Year	2037	2038	2039	2040	2041	2042
Inflated annual energy cost	4,540.35	4,449.55	4,360.55	4,273.34	4,187.88	4,104.12
Cumulative energy cost	104,103.21	108,552.75	112,913.31	117,186.65	121,374.53	125,478.65
Year	2043	2044	2045	2046	2047	2048
Inflated annual energy cost	4,022.04	3,941.60	3,862.76	3,785.51	3,709.80	3,635.60
Cumulative energy cost	129,500.69	133,442.28	137,305.05	141,090.56	144,800.36	148,435.96
Year	2049	2050	2051	2052	2053	2054
Inflated annual energy cost	3,562.89	3,491.63	3,421.80	3,353.36	3,286.30	3,220.57
Cumulative energy cost	151,998.85	155,490.48	158,912.28	162,265.65	165,551.94	168,772.51
Year	2055	2056	2057	2058	2059	2060
Inflated annual energy cost	3,156.16	3,093.04	3,031.18	2,970.55	2,911.14	2,852.92
Cumulative energy cost	171,928.67	175,021.71	178,052.89	181,023.44	183,934.58	186,787.50
Year	2061	2062	2063	2064	2065	2066
Inflated annual energy cost	2,795.86	2,739.94	2,685.14	2,631.44	2,578.81	2,527.24
Cumulative energy cost	189,583.36	192,323.30	195,008.45	197,639.89	200,218.70	202,745.94

Table B.1 (continued)

Year	2067	2068	2069	2070	2071	2072
Inflated annual energy cost	2,476.69	2,427.16	2,378.61	2,331.04	2,284.42	2,238.73
Cumulative energy cost	205,222.63	207,649.78	210,028.40	212,359.44	214,643.86	216,882.59
Year	2073	2074	2075	2076	2077	2078
Inflated annual energy cost	2,193.96	2,150.08	2,107.08	2,064.94	2,023.64	1,983.16
Cumulative energy cost	219,076.55	221,226.63	223,333.71	225,398.64	227,422.28	229,405.45
Year	2079	-	-	-	-	-
Inflated annual energy cost	1,943.50	-	-	-	-	-
Cumulative energy cost	231,348.95	-	-	-	-	-

TableB.2: Total estimated energy LCC for public schools in West Bank/Palestine with -1% energy inflation rate.

Total energy life cycle budget for public schools in West Bank/ Palestine (ILS), with -1% energy inflation rate						
Year	2019	2020	2021	2022	2023	2024
Inflated annual energy cost	6,531.61	6,466.29	6,401.63	6,337.61	6,274.24	6,211.50
Cumulative energy cost	6,531.61	12,997.90	19,399.53	25,737.15	32,011.39	38,222.88
Year	2025	2026	2027	2028	2029	2030
Inflated annual energy cost	6,149.38	6,087.89	6,027.01	5,966.74	5,907.07	5,848.00
Cumulative energy cost	44,372.27	50,460.15	56,487.16	62,453.90	68,360.97	74,208.97
Year	2031	2032	2033	2034	2035	2036
Inflated annual energy cost	5,789.52	5,731.63	5,674.31	5,617.57	5,561.39	5,505.78
Cumulative energy cost	79,998.49	85,730.12	91,404.43	97,021.99	102,583.38	108,089.16
Year	2037	2038	2039	2040	2041	2042
Inflated annual energy cost	5,450.72	5,396.21	5,342.25	5,288.83	5,235.94	5,183.58
Cumulative energy cost	113,539.88	118,936.09	124,278.34	129,567.16	134,803.10	139,986.68
Year	2043	2044	2045	2046	2047	2048
Inflated annual energy cost	5,131.74	5,080.43	5,029.62	4,979.33	4,929.53	4,880.24
Cumulative energy cost	145,118.42	150,198.85	155,228.47	160,207.80	165,137.33	170,017.56
Year	2049	2050	2051	2052	2053	2054
Inflated annual energy cost	4,831.43	4,783.12	4,735.29	4,687.94	4,641.06	4,594.65
Cumulative energy cost	174,849.00	179,632.12	184,367.41	189,055.34	193,696.40	198,291.05
Year	2055	2056	2057	2058	2059	2060
Inflated annual energy cost	4,548.70	4,503.21	4,458.18	4,413.60	4,369.46	4,325.77
Cumulative energy cost	202,839.75	207,342.96	211,801.14	216,214.74	220,584.20	224,909.97
Year	2061	2062	2063	2064	2065	2066
Inflated annual energy cost	4,282.51	4,239.69	4,197.29	4,155.32	4,113.76	4,072.62
Cumulative energy cost	229,192.48	233,432.16	237,629.45	241,784.77	245,898.53	249,971.15
Year	2067	2068	2069	2070	2071	2072
Inflated annual energy cost	4,031.90	3,991.58	3,951.66	3,912.15	3,873.03	3,834.30

Table B.2 (continued)

Cumulative energy cost	254,003.05	257,994.63	261,946.30	265,858.44	269,731.47	273,565.76
Year	2073	2074	2075	2076	2077	2078
Inflated annual energy cost	3,795.95	3,757.99	3,720.41	3,683.21	3,646.38	3,609.91
Cumulative energy cost	277,361.72	281,119.71	284,840.12	288,523.33	292,169.71	295,779.62
Year	2079	-	-	-	-	-
Inflated annual energy cost	3,573.81	-	-	-	-	-
Cumulative energy cost	299,353.43	-	-	-	-	-

TableB.3: Total estimated energy LCC for public schools in West Bank/Palestine with 0% energy inflation rate.

Total energy life cycle budget for public schools in West Bank/ Palestine (ILS), with 0% energy inflation rate						
Year	2019	2020	2021	2022	2023	2024
Inflated annual energy cost	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61
Cumulative energy cost	6,531.61	13,063.22	19,594.83	26,126.44	32,658.05	39,189.66
Year	2025	2026	2027	2028	2029	2030
Inflated annual energy cost	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61
Cumulative energy cost	45,721.27	52,252.88	58,784.49	65,316.10	71,847.71	78,379.32
Year	2031	2032	2033	2034	2035	2036
Inflated annual energy cost	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61
Cumulative energy cost	84,910.93	91,442.54	97,974.15	104,505.76	111,037.37	117,568.98
Year	2037	2038	2039	2040	2041	2042
Inflated annual energy cost	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61
Cumulative energy cost	124,100.59	130,632.20	137,163.81	143,695.42	150,227.03	156,758.64
Year	2043	2044	2045	2046	2047	2048
Inflated annual energy cost	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61
Cumulative energy cost	163,290.25	169,821.86	176,353.47	182,885.08	189,416.69	195,948.30
Year	2049	2050	2051	2052	2053	2054
Inflated annual energy cost	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61
Cumulative energy cost	202,479.91	209,011.52	215,543.13	222,074.74	228,606.35	235,137.96
Year	2055	2056	2057	2058	2059	2060
Inflated annual energy cost	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61
Cumulative energy cost	241,669.57	248,201.18	254,732.79	261,264.40	267,796.01	274,327.62
Year	2061	2062	2063	2064	2065	2066
Inflated annual energy cost	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61
Cumulative energy cost	280,859.23	287,390.84	293,922.45	300,454.06	306,985.67	313,517.28
Year	2067	2068	2069	2070	2071	2072
Inflated annual energy cost	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61
Cumulative energy cost	320,048.89	326,580.50	333,112.11	339,643.72	346,175.33	352,706.94

Table B.3 (continued)

Year	2073	2074	2075	2076	2077	2078
Inflated annual energy cost	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61	6,531.61
Cumulative energy cost	359,238.55	365,770.16	372,301.77	378,833.38	385,364.99	391,896.60
Year	2079	-	-	-	-	-
Inflated annual energy cost	6,531.61	-	-	-	-	-
Cumulative energy cost	398,428.21	-	-	-	-	-

Table B.4: Total estimated energy LCC for public schools in West Bank/Palestine with 3% energy inflation rate.

Total energy life cycle budget for public schools in West Bank/ Palestine (ILS), with 3% energy inflation rate						
Year	2019	2020	2021	2022	2023	2024
Inflated annual energy cost	6,531.61	6,727.56	6,929.39	7,137.27	7,351.38	7,571.93
Cumulative energy cost	6,531.61	13,259.17	20,188.55	27,325.82	34,677.20	42,249.13
Year	2025	2026	2027	2028	2029	2030
Inflated annual energy cost	7,799.08	8,033.06	8,274.05	8,522.27	8,777.94	9,041.28
Cumulative energy cost	50,048.21	58,081.27	66,355.32	74,877.59	83,655.53	92,696.80
Year	2031	2032	2033	2034	2035	2036
Inflated annual energy cost	9,312.51	9,591.89	9,879.65	10,176.04	10,481.32	10,795.76
Cumulative energy cost	102,009.32	111,601.21	121,480.85	131,656.89	142,138.20	152,933.96
Year	2037	2038	2039	2040	2041	2042
Inflated annual energy cost	11,119.63	11,453.22	11,796.81	12,150.72	12,515.24	12,890.70
Cumulative energy cost	164,053.59	175,506.81	187,303.62	199,454.34	211,969.58	224,860.28
Year	2043	2044	2045	2046	2047	2048
Inflated annual energy cost	13,277.42	13,675.74	14,086.01	14,508.59	14,943.85	15,392.17
Cumulative energy cost	238,137.70	251,813.44	265,899.45	280,408.04	295,351.89	310,744.06
Year	2049	2050	2051	2052	2053	2054
Inflated annual energy cost	15,853.93	16,329.55	16,819.44	17,324.02	17,843.74	18,379.05
Cumulative energy cost	326,597.99	342,927.54	359,746.98	377,071.00	394,914.74	413,293.79
Year	2055	2056	2057	2058	2059	2060
Inflated annual energy cost	18,930.42	19,498.34	20,083.29	20,685.79	21,306.36	21,945.55
Cumulative energy cost	432,224.21	451,722.55	471,805.84	492,491.62	513,797.98	535,743.53
Year	2061	2062	2063	2064	2065	2066
Inflated annual energy cost	22,603.92	23,282.03	23,980.49	24,699.91	25,440.91	26,204.13
Cumulative energy cost	558,347.45	581,629.48	605,609.97	630,309.88	655,750.79	681,954.92
Year	2067	2068	2069	2070	2071	2072
Inflated annual energy cost	26,990.26	27,799.97	28,633.96	29,492.98	30,377.77	31,289.11
Cumulative energy cost	708,945.18	736,745.15	765,379.11	794,872.09	825,249.87	856,538.97
Year	2073	2074	2075	2076	2077	2078
Inflated annual energy cost	32,227.78	33,194.61	34,190.45	35,216.16	36,272.65	37,360.83

Table B.4 (continued)

Cumulative energy cost	888,766.75	921,961.36	956,151.82	991,367.98	1,027,640.63	1,065,001.46
Year	2079	-	-	-	-	-
Inflated annual energy cost	38,481.65	-	-	-	-	-
Cumulative energy cost	1,103,483.11	-	-	-	-	-

Table B.5: Total estimated energy LCC for public schools in West Bank/Palestine with 5% energy inflation rate.

Total energy life cycle budget for public schools in West Bank/ Palestine (ILS), with 5% energy inflation rate						
Year	2019	2020	2021	2022	2023	2024
Inflated annual energy cost	6,531.61	6,858.19	7,201.10	7,561.16	7,939.21	8,336.17
Cumulative energy cost	6,531.61	13,389.80	20,590.90	28,152.06	36,091.27	44,427.44
Year	2025	2026	2027	2028	2029	2030
Inflated annual energy cost	8,752.98	9,190.63	9,650.16	10,132.67	10,639.30	11,171.27
Cumulative energy cost	53,180.42	62,371.06	72,021.22	82,153.89	92,793.19	103,964.46
Year	2031	2032	2033	2034	2035	2036
Inflated annual energy cost	11,729.83	12,316.32	12,932.14	13,578.75	14,257.69	14,970.57
Cumulative energy cost	115,694.30	128,010.62	140,942.76	154,521.51	168,779.20	183,749.77
Year	2037	2038	2039	2040	2041	2042
Inflated annual energy cost	15,719.10	16,505.05	17,330.31	18,196.82	19,106.66	20,062.00
Cumulative energy cost	199,468.86	215,973.92	233,304.22	251,501.04	270,607.71	290,669.70
Year	2043	2044	2045	2046	2047	2048
Inflated annual energy cost	21,065.10	22,118.35	23,224.27	24,385.48	25,604.75	26,884.99
Cumulative energy cost	311,734.80	333,853.15	357,077.41	381,462.89	407,067.65	433,952.64
Year	2049	2050	2051	2052	2053	2054
Inflated annual energy cost	28,229.24	29,640.70	31,122.74	32,678.88	34,312.82	36,028.46
Cumulative energy cost	462,181.88	491,822.59	522,945.33	555,624.20	589,937.02	625,965.48
Year	2055	2056	2057	2058	2059	2060
Inflated annual energy cost	37,829.88	39,721.38	41,707.45	43,792.82	45,982.46	48,281.58
Cumulative energy cost	663,795.37	703,516.75	745,224.19	789,017.01	834,999.47	883,281.06
Year	2061	2062	2063	2064	2065	2066
Inflated annual energy cost	50,695.66	53,230.45	55,891.97	58,686.57	61,620.90	64,701.94
Cumulative energy cost	933,976.72	987,207.17	1,043,099.14	1,101,785.70	1,163,406.60	1,228,108.54
Year	2067	2068	2069	2070	2071	2072
Inflated annual energy cost	67,937.04	71,333.89	74,900.58	78,645.61	82,577.89	86,706.79
Cumulative energy cost	1,296,045.57	1,367,379.46	1,442,280.05	1,520,925.66	1,603,503.55	1,690,210.34
Year	2073	2074	2075	2076	2077	2078
Inflated annual energy cost	91,042.13	95,594.23	100,373.94	105,392.64	110,662.27	116,195.39
Cumulative energy cost	1,781,252.46	1,876,846.70	1,977,220.64	2,082,613.29	2,193,275.56	2,309,470.95

Table B.5 (continued)

Year	2079	-	-	-	-	-
Inflated annual energy cost	122,005.16	-	-	-	-	-
Cumulative energy cost	2,431,476.10	-	-	-	-	-

Table B.6: Total estimated energy LCC for public schools in West Bank/Palestine with 7% energy inflation rate.

Total energy life cycle budget for public schools in West Bank/ Palestine (ILS), with 7% energy inflation rate						
Year	2019	2020	2021	2022	2023	2024
Inflated annual energy cost	6,531.61	6,988.82	7,478.04	8,001.50	8,561.61	9,160.92
Cumulative energy cost	6,531.61	13,520.43	20,998.47	28,999.98	37,561.58	46,722.51
Year	2025	2026	2027	2028	2029	2030
Inflated annual energy cost	9,802.19	10,488.34	11,222.52	12,008.10	12,848.67	13,748.07
Cumulative energy cost	56,524.69	67,013.03	78,235.55	90,243.65	103,092.32	116,840.39
Year	2031	2032	2033	2034	2035	2036
Inflated annual energy cost	14,710.44	15,740.17	16,841.98	18,020.92	19,282.38	20,632.15
Cumulative energy cost	131,550.82	147,290.99	164,132.97	182,153.89	201,436.27	222,068.42
Year	2037	2038	2039	2040	2041	2042
Inflated annual energy cost	22,076.40	23,621.75	25,275.27	27,044.54	28,937.66	30,963.29
Cumulative energy cost	244,144.82	267,766.57	293,041.84	320,086.38	349,024.03	379,987.32
Year	2043	2044	2045	2046	2047	2048
Inflated annual energy cost	33,130.72	35,449.87	37,931.36	40,586.56	43,427.62	46,467.55
Cumulative energy cost	413,118.05	448,567.92	486,499.28	527,085.84	570,513.46	616,981.02
Year	2049	2050	2051	2052	2053	2054
Inflated annual energy cost	49,720.28	53,200.70	56,924.75	60,909.48	65,173.15	69,735.27
Cumulative energy cost	666,701.30	719,902.00	776,826.75	837,736.23	902,909.38	972,644.64
Year	2055	2056	2057	2058	2059	2060
Inflated annual energy cost	74,616.74	79,839.91	85,428.70	91,408.71	97,807.32	104,653.83
Cumulative energy cost	1,047,261.38	1,127,101.28	1,212,529.98	1,303,938.69	1,401,746.01	1,506,399.84
Year	2061	2062	2063	2064	2065	2066
Inflated annual energy cost	111,979.60	119,818.17	128,205.44	137,179.82	146,782.41	157,057.18
Cumulative energy cost	1,618,379.44	1,738,197.61	1,866,403.06	2,003,582.88	2,150,365.29	2,307,422.47
Year	2067	2068	2069	2070	2071	2072
Inflated annual energy cost	168,051.18	179,814.77	192,401.80	205,869.93	220,280.82	235,700.48
Cumulative energy cost	2,475,473.66	2,655,288.42	2,847,690.22	3,053,560.15	3,273,840.97	3,509,541.44
Year	2073	2074	2075	2076	2077	2078
Inflated annual energy cost	252,199.51	269,853.48	288,743.22	308,955.25	330,582.11	353,722.86
Cumulative energy cost	3,761,740.95	4,031,594.43	4,320,337.65	4,629,292.90	4,959,875.01	5,313,597.87

Table B.6 (*continued*)

Year	2079	-	-	-	-	-
Inflated annual energy cost	378,483.46	-	-	-	-	-
Cumulative energy cost	5,692,081.33	-	-	-	-	-

B.2 Energy Life Cycle Cost Estimation for Aqqaba Green School/ Palestine

The energy life cycle cost analysis for Aqqaba green school using different energy inflation rates are illustrated in the following tables:

Table B.7: Total estimated energy LCC for Aqqaba green school with -2% energy inflation rate.

Total energy life cycle budget for Aqqaba green school (ILS), with -2% energy inflation rate						
Year	2019	2020	2021	2022	2023	2024
Inflated annual energy cost	6,155.69	6,032.58	5,911.92	5,793.69	5,677.81	5,564.26
Cumulative energy cost	6,155.69	12,188.27	18,100.19	23,893.88	29,571.69	35,135.95
Year	2025	2026	2027	2028	2029	2030
Inflated annual energy cost	5,452.97	5,343.91	5,237.03	5,132.29	5,029.65	4,929.05
Cumulative energy cost	40,588.92	45,932.83	51,169.86	56,302.15	61,331.80	66,260.86
Year	2031	2032	2033	2034	2035	2036
Inflated annual energy cost	4,830.47	4,733.86	4,639.19	4,546.40	4,455.47	4,366.36
Cumulative energy cost	71,091.33	75,825.19	80,464.38	85,010.78	89,466.25	93,832.62
Year	2037	2038	2039	2040	2041	2042
Inflated annual energy cost	4,279.04	4,193.46	4,109.59	4,027.40	3,946.85	3,867.91
Cumulative energy cost	98,111.66	102,305.11	106,414.70	110,442.10	114,388.95	118,256.86
Year	2043	2044	2045	2046	2047	2048
Inflated annual energy cost	3,790.55	3,714.74	3,640.45	3,567.64	3,496.29	3,426.36
Cumulative energy cost	122,047.41	125,762.15	129,402.60	132,970.24	136,466.52	139,892.88
Year	2049	2050	2051	2052	2053	2054
Inflated annual energy cost	3,357.83	3,290.68	3,224.86	3,160.36	3,097.16	3,035.21
Cumulative energy cost	143,250.71	146,541.39	149,766.25	152,926.62	156,023.77	159,058.99
Year	2055	2056	2057	2058	2059	2060
Inflated annual energy cost	2,974.51	2,915.02	2,856.72	2,799.59	2,743.59	2,688.72
Cumulative energy cost	162,033.50	164,948.52	167,805.24	170,604.82	173,348.42	176,037.14
Year	2061	2062	2063	2064	2065	2066
Inflated annual energy cost	2,634.95	2,582.25	2,530.60	2,479.99	2,430.39	2,381.78
Cumulative energy cost	178,672.09	181,254.33	183,784.94	186,264.93	188,695.32	191,077.10
Year	2067	2068	2069	2070	2071	2072
Inflated annual energy cost	2,334.15	2,287.46	2,241.72	2,196.88	2,152.94	2,109.88

Table B.7 (*continued*)

Cumulative energy cost	193,411.25	195,698.72	197,940.43	200,137.31	202,290.26	204,400.14
Year	2073	2074	2075	2076	2077	2078
Inflated annual energy cost	2,067.69	2,026.33	1,985.81	1,946.09	1,907.17	1,869.03
Cumulative energy cost	206,467.83	208,494.16	210,479.97	212,426.06	214,333.23	216,202.25
Year	2079	-	-	-	-	-
Inflated annual energy cost	1,831.64	-	-	-	-	-
Cumulative energy cost	218,033.90	-	-	-	-	-

Table B.8: Total estimated energy LCC for Aqqaba green school with -1% energy inflation rate.

Total energy life cycle budget for Aqqaba green school (ILS), with -1% energy inflation rate						
Year	2019	2020	2021	2022	2023	2024
Inflated annual energy cost	6,155.69	6,094.13	6,033.19	5,972.86	5,913.13	5,854.00
Cumulative energy cost	6,155.69	12,249.82	18,283.01	24,255.87	30,169.01	36,023.01
Year	2025	2026	2027	2028	2029	2030
Inflated annual energy cost	5,795.46	5,737.51	5,680.13	5,623.33	5,567.10	5,511.42
Cumulative energy cost	41,818.47	47,555.97	53,236.10	58,859.43	64,426.53	69,937.95
Year	2031	2032	2033	2034	2035	2036
Inflated annual energy cost	5,456.31	5,401.75	5,347.73	5,294.25	5,241.31	5,188.90
Cumulative energy cost	75,394.26	80,796.01	86,143.74	91,437.99	96,679.30	101,868.20
Year	2037	2038	2039	2040	2041	2042
Inflated annual energy cost	5,137.01	5,085.64	5,034.78	4,984.43	4,934.59	4,885.24
Cumulative energy cost	107,005.21	112,090.84	117,125.63	122,110.06	127,044.65	131,929.89
Year	2043	2044	2045	2046	2047	2048
Inflated annual energy cost	4,836.39	4,788.03	4,740.15	4,692.75	4,645.82	4,599.36
Cumulative energy cost	136,766.28	141,554.31	146,294.46	150,987.20	155,633.02	160,232.38
Year	2049	2050	2051	2052	2053	2054
Inflated annual energy cost	4,553.37	4,507.83	4,462.75	4,418.13	4,373.95	4,330.21
Cumulative energy cost	164,785.75	169,293.58	173,756.33	178,174.46	182,548.41	186,878.61
Year	2055	2056	2057	2058	2059	2060
Inflated annual energy cost	4,286.90	4,244.03	4,201.59	4,159.58	4,117.98	4,076.80
Cumulative energy cost	191,165.52	195,409.55	199,611.14	203,770.72	207,888.71	211,965.51
Year	2061	2062	2063	2064	2065	2066
Inflated annual energy cost	4,036.03	3,995.67	3,955.72	3,916.16	3,877.00	3,838.23
Cumulative energy cost	216,001.54	219,997.22	223,952.94	227,869.10	231,746.10	235,584.33
Year	2067	2068	2069	2070	2071	2072
Inflated annual energy cost	3,799.85	3,761.85	3,724.23	3,686.99	3,650.12	3,613.62
Cumulative energy cost	239,384.17	243,146.02	246,870.25	250,557.24	254,207.36	257,820.97
Year	2073	2074	2075	2076	2077	2078
Inflated annual energy cost	3,577.48	3,541.71	3,506.29	3,471.23	3,436.51	3,402.15

Table B.8 (continued)

Cumulative energy cost	261,398.45	264,940.16	268,446.45	271,917.67	275,354.18	278,756.33
Year	2079	-	-	-	-	-
Inflated annual energy cost	3,368.13	-	-	-	-	-
Cumulative energy cost	282,124.46	-	-	-	-	-

Table B.9: Total estimated energy LCC for Aqqaba green school with 0% energy inflation rate.

Total energy life cycle budget for Aqqaba green school (ILS), with 0% energy inflation rate						
Year	2019	2020	2021	2022	2023	2024
Inflated annual energy cost	6155.69	6155.69	6155.69	6155.69	6155.69	6155.69
Cumulative energy cost	6,155.69	12,311.38	18,467.07	24,622.76	30,778.45	36,934.14
Year	2025	2026	2027	2028	2029	2030
Inflated annual energy cost	6155.69	6155.69	6155.69	6155.69	6155.69	6155.69
Cumulative energy cost	43,089.83	49,245.52	55,401.21	61,556.90	67,712.59	73,868.28
Year	2031	2032	2033	2034	2035	2036
Inflated annual energy cost	6155.69	6155.69	6155.69	6155.69	6155.69	6155.69
Cumulative energy cost	80,023.97	86,179.66	92,335.35	98,491.04	104,646.73	110,802.42
Year	2037	2038	2039	2040	2041	2042
Inflated annual energy cost	6155.69	6155.69	6155.69	6155.69	6155.69	6155.69
Cumulative energy cost	116,958.11	123,113.80	129,269.49	135,425.18	141,580.87	147,736.56
Year	2043	2044	2045	2046	2047	2048
Inflated annual energy cost	6155.69	6155.69	6155.69	6155.69	6155.69	6155.69
Cumulative energy cost	153,892.25	160,047.94	166,203.63	172,359.32	178,515.01	184,670.70
Year	2049	2050	2051	2052	2053	2054
Inflated annual energy cost	6155.69	6155.69	6155.69	6155.69	6155.69	6155.69
Cumulative energy cost	190,826.39	196,982.08	203,137.77	209,293.46	215,449.15	221,604.84
Year	2055	2056	2057	2058	2059	2060
Inflated annual energy cost	6155.69	6155.69	6155.69	6155.69	6155.69	6155.69
Cumulative energy cost	227,760.53	233,916.22	240,071.91	246,227.60	252,383.29	258,538.98
Year	2061	2062	2063	2064	2065	2066
Inflated annual energy cost	6155.69	6155.69	6155.69	6155.69	6155.69	6155.69
Cumulative energy cost	264,694.67	270,850.36	277,006.05	283,161.74	289,317.43	295,473.12
Year	2067	2068	2069	2070	2071	2072
Inflated annual energy cost	6155.69	6155.69	6155.69	6155.69	6155.69	6155.69
Cumulative energy cost	301,628.81	307,784.50	313,940.19	320,095.88	326,251.57	332,407.26
Year	2073	2074	2075	2076	2077	2078
Inflated annual energy cost	6155.69	6155.69	6155.69	6155.69	6155.69	6155.69
Cumulative energy cost	338,562.95	344,718.64	350,874.33	357,030.02	363,185.71	369,341.40

Table B.9 (continued)

Year	2079	-	-	-	-	-
Inflated annual energy cost	6,155.69	-	-	-	-	-
Cumulative energy cost	375,497.09	-	-	-	-	-

Table B.10: Total estimated energy LCC for Aqqaba green school with 3% energy inflation rate.

Total energy life cycle budget for Aqqaba green school (ILS), with 3% energy inflation rate						
Year	2019	2020	2021	2022	2023	2024
Inflated annual energy cost	6,155.69	6,340.36	6,530.57	6,726.49	6,928.28	7,136.13
Cumulative energy cost	6,155.69	12,496.05	19,026.62	25,753.11	32,681.39	39,817.53
Year	2025	2026	2027	2028	2029	2030
Inflated annual energy cost	7,350.22	7,570.72	7,797.84	8,031.78	8,272.73	8,520.91
Cumulative energy cost	47,167.74	54,738.46	62,536.31	70,568.09	78,840.82	87,361.73
Year	2031	2032	2033	2034	2035	2036
Inflated annual energy cost	8,776.54	9,039.84	9,311.03	9,590.36	9,878.08	10,174.42
Cumulative energy cost	96,138.28	105,178.11	114,489.15	124,079.51	133,957.59	144,132.01
Year	2037	2038	2039	2040	2041	2042
Inflated annual energy cost	10,479.65	10,794.04	11,117.86	11,451.40	11,794.94	12,148.79
Cumulative energy cost	154,611.66	165,405.70	176,523.56	187,974.95	199,769.89	211,918.68
Year	2043	2044	2045	2046	2047	2048
Inflated annual energy cost	12,513.25	12,888.65	13,275.31	13,673.57	14,083.77	14,506.29
Cumulative energy cost	224,431.93	237,320.58	250,595.88	264,269.45	278,353.22	292,859.51
Year	2049	2050	2051	2052	2053	2054
Inflated annual energy cost	14,941.48	15,389.72	15,851.41	16,326.95	16,816.76	17,321.26
Cumulative energy cost	307,800.99	323,190.71	339,042.12	355,369.07	372,185.83	389,507.10
Year	2055	2056	2057	2058	2059	2060
Inflated annual energy cost	17,840.90	18,376.13	18,927.41	19,495.24	20,080.09	20,682.50
Cumulative energy cost	407,348.00	425,724.13	444,651.54	464,146.78	484,226.87	504,909.37
Year	2061	2062	2063	2064	2065	2066
Inflated annual energy cost	21,302.97	21,942.06	22,600.32	23,278.33	23,976.68	24,695.98
Cumulative energy cost	526,212.34	548,154.40	570,754.72	594,033.06	618,009.74	642,705.72
Year	2067	2068	2069	2070	2071	2072
Inflated annual energy cost	25,436.86	26,199.97	26,985.97	27,795.55	28,629.41	29,488.29
Cumulative energy cost	668,142.58	694,342.55	721,328.51	749,124.06	777,753.47	807,241.77
Year	2073	2074	2075	2076	2077	2078
Inflated annual energy cost	30,372.94	31,284.13	32,222.66	33,189.33	34,185.01	35,210.57
Cumulative energy cost	837,614.71	868,898.84	901,121.50	934,310.83	968,495.85	1,003,706.41
Year	2079	-	-	-	-	-
Inflated annual energy cost	36,266.88	-	-	-	-	-
Cumulative energy cost	1,039,973.29	-	-	-	-	-

Table B.11: Total estimated energy LCC for Aqqaba green school with 5% energy inflation rate.

Total energy life cycle budget for Aqqaba green school (ILS), with 5% energy inflation rate						
Year	2019	2020	2021	2022	2023	2024
Inflated annual energy cost	6,155.69	6,463.47	6,786.65	7,125.98	7,482.28	7,856.39
Cumulative energy cost	6,155.69	12,619.16	19,405.81	26,531.79	34,014.07	41,870.47
Year	2025	2026	2027	2028	2029	2030
Inflated annual energy cost	8,249.21	8,661.67	9,094.76	9,549.50	10,026.97	10,528.32
Cumulative energy cost	50,119.68	58,781.35	67,876.11	77,425.61	87,452.58	97,980.90
Year	2031	2032	2033	2034	2035	2036
Inflated annual energy cost	11,054.73	11,607.47	12,187.85	12,797.24	13,437.10	14,108.95
Cumulative energy cost	109,035.63	120,643.10	132,830.95	145,628.19	159,065.28	173,174.24
Year	2037	2038	2039	2040	2041	2042
Inflated annual energy cost	14,814.40	15,555.12	16,332.88	17,149.52	18,007.00	18,907.35
Cumulative energy cost	187,988.64	203,543.76	219,876.64	237,026.16	255,033.16	273,940.51
Year	2043	2044	2045	2046	2047	2048
Inflated annual energy cost	19,852.72	20,845.35	21,887.62	22,982.00	24,131.10	25,337.65
Cumulative energy cost	293,793.22	314,638.58	336,526.19	359,508.19	383,639.29	408,976.95
Year	2049	2050	2051	2052	2053	2054
Inflated annual energy cost	26,604.54	27,934.76	29,331.50	30,798.08	32,337.98	33,954.88
Cumulative energy cost	435,581.49	463,516.25	492,847.75	523,645.83	555,983.81	589,938.69
Year	2055	2056	2057	2058	2059	2060
Inflated annual energy cost	35,652.62	37,435.26	39,307.02	41,272.37	43,335.99	45,502.79
Cumulative energy cost	625,591.32	663,026.57	702,333.59	743,605.96	786,941.95	832,444.74
Year	2061	2062	2063	2064	2065	2066
Inflated annual energy cost	47,777.93	50,166.82	52,675.16	55,308.92	58,074.37	60,978.09
Cumulative energy cost	880,222.66	930,389.49	983,064.65	1,038,373.58	1,096,447.94	1,157,426.03
Year	2067	2068	2069	2070	2071	2072
Inflated annual energy cost	64,026.99	67,228.34	70,589.76	74,119.25	77,825.21	81,716.47
Cumulative energy cost	1,221,453.02	1,288,681.36	1,359,271.12	1,433,390.37	1,511,215.58	1,592,932.05
Year	2073	2074	2075	2076	2077	2078
Inflated annual energy cost	85,802.29	90,092.41	94,597.03	99,326.88	104,293.22	109,507.88
Cumulative energy cost	1,678,734.34	1,768,826.74	1,863,423.77	1,962,750.65	2,067,043.87	2,176,551.76
Year	2079	-	-	-	-	-
Inflated annual energy cost	114,983.28	-	-	-	-	-
Cumulative energy cost	2,291,535.03	-	-	-	-	-

Table B.12: Total estimated energy LCC for Aqqaba green school with 7% energy inflation rate.

Total energy life cycle budget for Aqqaba green school (ILS), with 7% energy inflation rate						
Year	2019	2020	2021	2022	2023	2024
Inflated annual energy cost	6,155.69	6,586.59	7,047.65	7,540.98	8,068.85	8,633.67
Cumulative energy cost	6,155.69	12,742.28	19,789.93	27,330.91	35,399.77	44,033.44
Year	2025	2026	2027	2028	2029	2030
Inflated annual energy cost	9,238.03	9,884.69	10,576.62	11,316.98	12,109.17	12,956.82
Cumulative energy cost	53,271.47	63,156.16	73,732.79	85,049.77	97,158.94	110,115.76
Year	2031	2032	2033	2034	2035	2036
Inflated annual energy cost	13,863.79	14,834.26	15,872.66	16,983.74	18,172.60	19,444.69
Cumulative energy cost	123,979.55	138,813.81	154,686.47	171,670.21	189,842.82	209,287.50
Year	2037	2038	2039	2040	2041	2042
Inflated annual energy cost	20,805.82	22,262.22	23,820.58	25,488.02	27,272.18	29,181.23
Cumulative energy cost	230,093.32	252,355.54	276,176.12	301,664.14	328,936.32	358,117.55
Year	2043	2044	2045	2046	2047	2048
Inflated annual energy cost	31,223.92	33,409.59	35,748.26	38,250.64	40,928.19	43,793.16
Cumulative energy cost	389,341.47	422,751.06	458,499.33	496,749.97	537,678.16	581,471.32
Year	2049	2050	2051	2052	2053	2054
Inflated annual energy cost	46,858.68	50,138.79	53,648.51	57,403.90	61,422.17	65,721.73
Cumulative energy cost	628,330.00	678,468.79	732,117.30	789,521.20	850,943.37	916,665.10
Year	2055	2056	2057	2058	2059	2060
Inflated annual energy cost	70,322.25	75,244.80	80,511.94	86,147.78	92,178.12	98,630.59
Cumulative energy cost	986,987.34	1,062,232.15	1,142,744.09	1,228,891.86	1,321,069.98	1,419,700.57
Year	2061	2062	2063	2064	2065	2066
Inflated annual energy cost	105,534.73	112,922.16	120,826.71	129,284.58	138,334.50	148,017.92
Cumulative energy cost	1,525,235.30	1,638,157.46	1,758,984.18	1,888,268.76	2,026,603.26	2,174,621.18
Year	2067	2068	2069	2070	2071	2072
Inflated annual energy cost	158,379.17	169,465.71	181,328.31	194,021.30	207,602.79	222,134.98
Cumulative energy cost	2,333,000.35	2,502,466.07	2,683,794.38	2,877,815.68	3,085,418.46	3,307,553.45
Year	2073	2074	2075	2076	2077	2078
Inflated annual energy cost	237,684.43	254,322.34	272,124.91	291,173.65	311,555.80	333,364.71
Cumulative energy cost	3,545,237.88	3,799,560.22	4,071,685.13	4,362,858.77	4,674,414.58	5,007,779.29
Year	2079	-	-	-	-	-
Inflated annual energy cost	356,700.24	-	-	-	-	-
Cumulative energy cost	5,364,479.53	-	-	-	-	-

Appendix C

The Building energy index (BEI) for public schools in West Bank/Palestine illustrated in tables below:

Table C.1: BEI (kWh/year/m^2) for public schools with same area (±250 m^2) as Aqqaba green school area.

	School name	Region	Gender	School building area(m^2)	Average annual electricity consumption (kWh/year)	Building energy index per meter square (kWh/m^2/year)
1	Abdulmagith Al - Ansari elementary boys	Nablus	Males	1,625.00	7,513.60	4.62
2	Yasid secondary school for girls	Nablus	Females	1,250.00	4,096.80	3.28
3	Abdul Rahim Jardaneh secondary boys school	Nablus	Males	1,453.00	10,060.40	6.92
4	Zafer Al Masri secondary school for girls	Nablus	Females	1,225.00	12,295.80	10.04
5	Ruhi Alhindi elementary boys school/Tel	Nablus	Males	1,300.00	4,837.60	3.72
6	Saeed Bin Amer secondary school for girls	Nablus	Females	1,510.00	9,923.80	6.57
7	Talouzeh secondary mixed school	Nablus	Mixed	1,400.00	7,127.80	5.09
8	Nusseibeh Almaznieh elementary school for girls	Jenin	Females	1,570.00	10,579.40	6.74
9	Al-Salam secondary school for boys	Jenin	Males	1,272.00	14,184.80	11.15
10	Alshahida Kadoura Moussa elementary school for girls	Jenin	Females	1,434.70	9,501.60	6.62
11	Walid Abu Mowais elementary girls school	Jenin	Females	1,364.00	13,050.20	9.57
12	Anin elementary girls school	Jenin	Females	1,630.00	3,975.20	2.44
13	Al-Tirah mixed secondary school	Ramallah	Mixed	1,337.22	8,402.60	6.28
14	Abwain secondary mixed school	Ramallah	Mixed	1,480.00	6,639.80	4.49
15	Bil'in secondary girls school	Ramallah	Females	1,640.00	11,352.60	6.92
16	Shabtin secondary mixed school	Ramallah	Mixed	1,520.00	6,301.20	4.15
17	Kubar elementary boys school	Ramallah	Males	1,440.00	9,789.20	6.80
18	Singel high elementary males school*	Ramallah	Males	1,332.00	13,769.00	10.34
Average						6.43

Table C.2: BEI (kWh/year/student) for public schools with same number of students (±50 student) as Aqqaba green school number of students.

	School name	Region	Gender	Total number of students	School building area(m^2)	Average annual electricity consumption (kWh/year)	Building energy index per student (kWh/Student/year)
1	Khadija om Al-Mouminine mixed elementary school	Nablus	Mixed	164.00	323.00	3,960.20	24.15
2	Yousef Al - Barqawi elementary boys school	Nablus	Males	100.00	598.00	5,394.20	53.94
3	Azmout elementary girls school	Nablus	Females	154.00	450.00	2,903.60	18.85
4	Abn-Seena elementary girls school	Nablus	Females	161.00	640.00	5,672.60	35.23
5	Alnizamia (B) elementary school for girls	Nablus	Females	154.00	1,000.00	3,791.60	24.62
6	Burhan Kamal elementary school for boys	Nablus	Males	158.00	1,092.00	7,143.60	45.21
7	Ruhi Alhindi elementary boys school/Tel	Nablus	Males	140.00	1,300.00	4,837.60	34.55
8	Mohammed bin Rashid Al Maktoum elementary boys school	Nablus	Males	193.00	2,640.00	5,327.20	27.60
9	Alshahid Salah Khalaf elementary school for boys	Jenin	Males	171.00	380.00	2,597.80	15.19
10	Betaine secondary boys school	Ramallah	Males	178.00	564.00	6,253.40	35.13
11	Ain Yabroud mixed elementary school	Ramallah	Mixed	183.00	600.00	7,214.60	39.42
12	Sorda mixed elementary school	Ramallah	Mixed	168.00	1,114.00	6,181.80	36.80
13	Jalgilia mixed elementary school	Ramallah	Mixed	109.00	820.00	7,269.20	66.69
14	Kubar elementary boys school	Ramallah	Males	186.00	1,440.00	9,789.20	52.63
15	Kubar secondary girls school	Ramallah	Females	113.00	386.00	3,932.40	34.80
16	Al-Janiah mixed secondary school	Ramallah	Mixed	179.00	4,600.00	5,830.40	32.57
Average							36.09

Table C.3: BEI for public schools with same areas (±250 m^2) and number of students (±50 student) as Aqqaba green school.

	School Name	Number of students	School building area(m^2)	Average annual electricity consumption (kWh/year)	Building energy index per meter square (kWh/m²/year)	Building energy index per student (kWh/Student/year)
1	Ruhi Alhindi elementary boys school/Tel	140.00	1,300.00	4,837.60	3.72	34.55
2	Kubar elementary boys school	186.00	1,440.00	9,789.20	6.80	52.63
Average					5.26	43.59

جامعة النجاح الوطنية

كلية الدراسات العليا

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قدمت هذه الأطروحة استكمالاً لمتطلبات الحصول على درجة الماجستير في الادارة الهندسية، بكلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس– فلسطين.

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الملخص

على الرغم من أن العديد من الدراسات الأدبية تشير إلى أن المباني الخضراء متفوقة على المباني التقليدية (غير الخضراء) فيما يتعلق بالمنافع الاقتصادية، إلى أن حركة المباني الخضراء لا تزال ناشئة في فلسطين، حيث أن القليل من المباني مسجلة رسميًا ومصنفة على أنها مباني خضراء من قبل هيئات الإعتماد الرسمية.

تشير الدراسات أيضا إلى أن أصحاب المباني ومطوري العقارات لا يزالون مترددين في تبني مفهوم المباني الخضراء. حيث تتمركز العوامل الإقتصادية في طليعة العوامل التي تؤثر على قرارات المالكين بتبني مفهوم الأبنية الخضراء.

في هذا البحث، وبسبب الحاجة إلى تعزيز الأدلة التجريبية للفوائد الاقتصادية المرتبطة بانخفاض استهلاك الطاقة في المدارس الخضراء محليًا وعالميًا، فقد تم القيام بإجراء تحليل لتكلفة دورة حياة الطاقة لأول مدرسة خضراء مسجلة رسميًا في الضفة الغربية/ فلسطين.

منهجيًا، تم انشاء مرجعية (Baseline) لتكلفة دورة حياة الطاقة لاستهلاك الطاقة في لمدارس الحكومية (غير الخضراء) في فلسطين، حيث ان وجود مرجعية (Baseline) لاستهلاك الطاقة ضروري لقياس الأداء الاقتصادي الفعلي للمدرسة الخضراء من حيث استهلاك الطاقة. ثم تم استخدام تكلفة دورة الحياة كأسلوب تقييم اقتصادي عن طريق تحليل تكلفة دورة الحياة باستخدام سيناريوهات مختلفة لتضخم أسعار الطاقة لمعرفة كيفية تأثير هذه السيناريوهات على توفير

التكاليف المرتبطة بانخفاض استهلاك الطاقة في المدرسة الخضراء مقارنةً بالمدارس الحكومية في الضفة الغربية بفلسطين على مدى دورة حياتها والتي تمتد لمدة 60 سنة.

لقد وجد في هذا البحث أن معدل استهلاك الطاقة في المدارس الحكومية في الضفة الغربية بفلسطين يبلغ 10,367.63 كيلو واط ساعة/ سنويًا، وهو ما يكافىء معامل أداء طاقة (BEI) 8.34 كيلو واط/ ساعة/ سنوياً. ومن منظور دورة الحياة، وجد أن تكلفة دورة حياة الطاقة للمدارس الحكومية (غير الخضراء) تبلغ 766,370.59 شيكل إسرائيلي عند معدل زيادة سنوية 2% في أسعار الطاقة. في حين ان معدل استهلاك الطاقة بالمدرسة الخضراء يبلغ 8,895.50 كيلو واط/ سنوياً، وهو ما يكافىء معامل أداء طاقة (BEI) 6.32 كيلو واط / ساعة/ سنوياً. ومن منظور دورة الحياة، وجد أن تكلفة دورة حياة الطاقة للمدرسة الخضراء تبلغ 722,262.93 شيكل إسرائيلي عند معدل زيادة سنوية 2% في أسعار الطاقة. كما وجد ايضاً ان المدرسة الخضراء في ضوء استهلاك الطاقة توفر ما نسبته 24.22% مقارنةً مع المدراس الحكومية (غير الخضراء) بفلسطين.

أيضاً من منظور دورة الحياة أظهرت النتائج أن نظام الخلايا الشمسية المتواجد بالمدرسة الخضراء يوفر 284,187.70 شيكل إسرائيلي عند معدل زيادة سنوية 2% في أسعار الطاقة، وهو ما يمثل نسبة 86.56% من حجم التوفير بالطاقة خلال دورة حياتها.