View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Universiti Teknologi Malaysia Institutional Repository

PERFORMANCE OF OFFICE BUILDING INTEGRATED PHOTOVOLTAIC FOR WINDOWS UNDER SEMI-ARID CLIMATE IN ALGERIA

MESLOUB ABDELHAKIM

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctorate of Philosophy

Faculty of Built Environment and Surveying
Universiti Teknologi Malaysia

March 2019

DEDECATION

To my beloved parents, wife, my daughter Leen, sisters and friends

ACKNOWLEDGMENTS

In the Name of Allah, the Beneficent, the Merciful. First of all, I must give thanks to Allah who gave me the ability, patience and has helped me to complete this study. Peace and blessing be upon our prophet Mohammed.

I would like to express special thanks and gratitude to my supervisor Assoc. Prof. Dr. Mohd Zin bin Kandar for his guidance, patience, dedication, and encouragement during my study at UTM. I have the highest respect to Dr.Dodo Yakubu and admiration for his generous support and guidance during all stages in my PhD degree.

I would like to give further thanks to those people who supported me in carrying out this research. Especially, my beloved parents, wife, sisters and my Aunts for their support and constant encouragement to me during my study. They have always asked Allah to help me in their prayers. May Allah bless and protect them.

ABSTRACT

Building integrated photovoltaic (BIPV) has become the most significant alternative form of renewable energy for producing clean energy and to protect the environment. In Algeria, some problems arise due to the high energy consumption levels of building sector. Large amounts of this energy are lost through the external envelope façade, because of poor window design. Therefore, this research aimed to investigate the optimum BIPV windows performance for overall energy consumption (OEC) in typical office buildings in the semi-arid climate. Field measurements on a tested office building were carried out during the spring and summer seasons for the calibration and validation of Energy-plus and Integrated Environment Solution Virtual Environment (IES-VE) software. The data was analysed and used to develop a model for (OEC) simulation. The results of the investigation from the site measurements show that the BIPV window application provides a sufficient quantity of uniform daylight with only 20% Visible Light Transmittance (VLT), plus a comfortable indoor temperature and a considerable amount of clean energy production. The base-model and nine commercially-available BIPV modules, with different Window Wall Ratio (WWR), cardinal orientation and tilt angles were applied in an extensive simulation exercise. The simulation was carried out using Energy-plus to evaluate the energy generated through simple and equivalent one-diode models. The thermal performance used the Ideal load Air System (ILAS) model. In addition to IES-VE for the assessment of visual comfort and daylighting performance, through a combination of daylight control method, Useful Daylight Illuminance (UDI) and CEI glare index (CGI) were done. The results from this study revealed that the optimum BIPV window design differentiates in each orientation; which is the double glazing PV modules (A) with medium WWR and 20% VLT in the Southern facade, 30% VLT toward the East-West axis. Meanwhile, the North orientation is not suitable the application of BIPV window. The Maximum energy saving can be obtained with a 60% toward the South orientation by double glazing PV module (D). On the other hand, the PV modules minimize significantly the glare index comparing the base-model. The result established that the energy output percentages in a 3D model can be used by architects and designers in the early stages of design. Thus, the adoption of optimum BIPV window shows a significant improvement of the overall energy saving and visual comfort to deem them as an essential application in the semi-arid climate.

ABSTRAK

Bangunan Fotovoltaik bersepadu (BIPV) telah menjadi alternatif yang paling penting untuk tenaga boleh diperbaharui bagi menghasilkan tenaga bersih dan juga untuk melindungi alam sekitar. Di Algeria, beberapa masalah timbul disebabkan tahap penggunaan tenaga tinggi sektor bangunan. Sejumlah besar tenaga ini hilang melalui permukaan luar bangunan disebabkan oleh reka bentuk tingkap yang lemah. Oleh itu, kajian ini bertujuan untuk mengkaji prestasi tingkap BIPV yang optimum untuk penggunaan tenaga keseluruhan (OEC) di bangunan pejabat biasa di bawah iklim separa gersang. Ukuran lapangan bagi pejabat yang diuji telah dilakukan pada musim bunga dan musim panas untuk tujuan kalibrasi dan validasi perisian *Energy-plus* dan *Integrated Environment Solution Virtual Environment (IES-VE)*. Data telah dianalisis dan digunakan untuk membangunkan model untuk simulasi (OEC). Keputusan kajian dari pengukuran di tapak menunjukkan bahawa aplikasi tetingkap BIPV menyediakan kuantiti yang mencukupi dan pencahayaan siang seragam, dengan hanya 20%, Transmisi Cahaya Boleh Dilihat (VLT) ditambah dengan suhu dalaman yang selesa dan pengeluaran tenaga bersih yang banyak. Model asas dan sembilan modul BIPV yang tersedia secara komersial, dengan Nisbah Dinding Tingkap (WWR) yang berbeza, orientasi kardinal dan sudut condong digunakan untuk latihan simulasi yang menyeluruh. Simulasi dijalankan menggunakan *Energy-plus* untuk menilai tenaga melalui model satu-diod yang sederhana, bersamaan dengan prestasi terma menggunakan model Sistem Udara Beban Ideal (ILAS). Sebagai tambahan kepada Persekitaran Maya Penyelesaian Alam Sekitar Bersepadu (IES-VE) untuk penilaian keselesaan visual dan pencahayaan siang hari, melalui gabungan kaedah kawalan siang hari, pencahayaan siang hari yang berguna (UDI) dan CEI indeks silau (CGI), dilaksanakan daripada kajian ini mendedahkan bahawa Reka bentuk tetingkap BIPV optimum dibezakan mengikut, setiap orientasi; yang merupakan modul PV kaca berganda (A) dengan WWR sederhana dan 20% di permukaan Selatan, 30% VLT ke arah paksi Timur-Barat. Sementara itu, orientasi Utara tidak sesuai untuk penggunaan tetingkap BIPV. Penjimatan tenaga maksimum sehingga 60% bagi orientasi Selatan menggunakan PV kaca berganda (D). Modul PV meminimumkan secara ketara indeks silau berbanding dengan model asas. Hasil kajian telah menetapkan bahawa peratusan penghasilan tenaga dalam model 3D boleh digunakan oleh arkitek dan pereka pada peringkat awal rekabentuk. Justeru, penggunaan tetingkap BIPV yang optimum menunjukkan penambahbaikan yang ketara terhadap penjimatan tenaga dan keselesaan visual secara keseluruhan dan ia boleh dianggap sebagai aplikasi penting di kawasan iklim separa gersang.

TABLE OF CONTENTS

LIST OF TABLES

TABLE NO. **TITLE** **PAGE**

LIST OF FIGURES

FIGURE NO. **TITLE** **PAGE**

LIST OF ABBREVIATIONS

BIPV	-	Building Integrated Photovoltaic
BAPV	-	Building Added Photovoltaic
IEA	-	International Energy Agency
APRUE	-	Agency for the Promotion and Rational Use of Energy
CREDEG	-	Electricity & Gas R&D Center
UDTS	-	Unit for the development of silicium technology
CDER	-	Centre for Renewable Energy Development
UDES	-	Unit for Developing Solar Equipment
NEAL	-	New Energy Algeria Company Specialized in Development of Renewable Energy
OEC	-	Overall Energy Consumption
STC	-	Standard Test Condition
UDI	-	Useful Daylight Illuminance
DA	-	Daylight Autonomy
Lux	-	Unit of illuminance
CEI	-	Commission International d’eclairage
W	-	Watt
kWh	-	Kilo-watt Hour
IES-VE	-	Integrated Environment Solution Virtual Environment
FC	-	Foot-Candle
Ei	-	Exterior illuminance
ii	-	interior illuminance
m	-	meter
η	-	Efficiency of Module
Pmax	-	Max power
Vpm	-	Max power Voltage
Ipm	-	Max power Current
WWR	-	Windows Wall Ratio
WPI	-	Work Plane Illuminance
DF	-	Daylight Factor
VLT	-	Visible Light Transmittance
SHGC	-	Solar Heat Gain Coefficient
N	-	North
S	-	South
E	-	East
W	-	West
S-E	-	South-east
S-W	-	South-west
N-E	-	North-east
N-W	-	North-west
MBE	-	Mean Bias Error
CVRMSE	-	Coefficient Variation of Root Means Square Error
GHI	-	Global Horizontal Irradiance

DHI	-	Direct Horizontal Irradiance
CGI	-	CEI Glare Index
GVCP	-	Guth Visual comfort possibility
DGI	-	Daylight Glare Index
URG	-	Unified Glare index
DGP	-	Daylight Glare Index
CdTe	-	Cadmium Telluride
Mu-Si	-	Micro-morph Silicon
a-Si	-	Amorphous silicon
CIGS	-	Copper Indium gallium diselendide
OPV	-	Organic Photovoltaic
DSSCs	-	Dye sensitised solar cells
m-Si	-	Mono-crystalline
STPV	-	Semi-transparent Photovoltaic
PV-IGU	-	Photovoltaic insulated glass unit
PV-DFS	-	Photovoltaic Double skin facade
NEB	-	Net Electricity Benefit
ZEB	-	Zero Energy Building

LIST OF APPENDICES

CHAPTER 1

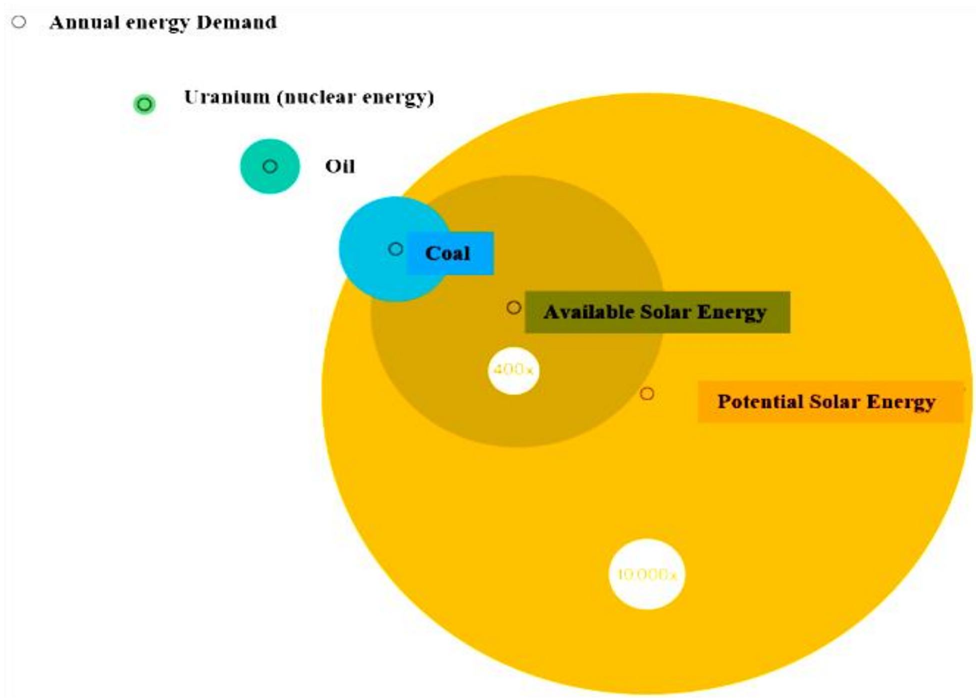
INTRODUCTION

1.1 Background

Sustainable developments in the field of architecture are turning out to be increasingly vital which requires the utilization of renewable energy and the reduction of energy consumption. The effect of global warming is the result of pollutant emissions from both traditional and conventional energy resources which takes account of the reduction of fossil fuel, intensification of oil consumption and the increment in the energy demand (Stoppato, 2008). These concerns have led to the emergence of significant development of renewable energy industries. Several studies show that this new sector played a vital role and many countries such as Algeria have taken measures to ensure sustainability of the utilization of global alternative energy resources (Hui, 1997; A Boudghene Stambouli, Khiat, Flazi, & Kitamura, 2012).

According to International Energy Agency (IEA) world council, solar energy is natural and a clean energy source as the current availability of the energy surpasses the annual energy demand by 400 times, whereas its potential surpasses the demand by 10,000 times. The sun will provide roughly limitless energy for the next 4-5 billion years (IEA, 2013) as shown in the Figure1.1. Hepbasli (2008) stated that solar energy resource such as photovoltaic is commonly used along with the leading technologies such as geothermal, biomass and hydroelectric energy. According to the Renewable Energy Policy Network for the 21st Century (REN21), there has been a noticeable growth by 55% in the utilization of photovoltaic (PV) as it is considered to be the most substantial energy resources available. In addition, study by Zahedi (2006) found that it is expected that solar PV electric's capacity worldwide shown to incline tremendously by 2030 from 1,000 MW in 2000 to 140,000 MW. By 2040, the renewable electric energy may possibly become adequate to support the base load and half of the global electricity energy demand claimed by the European Renewable Energy Council (Teske, Zervos, & Schäfer, 2007). Further, studies shows that the amount of solar electricity produced surpasses the global need as projected by the solar pyramid in the case of the Algerian Sahara with 50% of the space, 10% of the system energy efficiency and 14% PV module coverage (A Boudghene Stambouli et al., 2012).

Figure 1.1: : The amount of solar energy could be exploited, source: (IEA, 2013)



In this decade, the ability to fully utilize renewable energy innovation in building as well as environmental sustainability is the main topic for human societies around the planet. Many researchers such as (Huijts, Molin, & Steg, 2012; Rogers, Simmons, Convery, & Weatherall, 2008; Vlek & Steg, 2007; Wüstenhagen, Wolsink, & Bürer, 2007) stated that quality is taken into account of all countries in short and long term of natural resources, sustainable development and in addition to the technology used to designate economic, social, and environmental dimensions of our upcoming survival. According to Intissar Fakir (2016), low oil prices affects immensely on Algeria's finances and energy use leaving the economy at struggle in 2016. Alternatively, Algeria is interested to supplant fossil fuels and natural Gas with renewable energy resources. However, , it is a challenge for the government to promote renewable energy to minimize the utilization of energy in buildings as it is a new sector in the country (Himri, Malik, Stambouli, Himri, & Draoui, 2009; A Boudghene Stambouli et al., 2012).

Across all nations, the sector of energy consumption in buildings alone consumes around 20% to 60% of the overall account that is used by all sectors, and an average of about 31% worldwide. Algeria, a standout amongst the most nations on the planet's energy utilization assessed 42% more than the average by more than 10% as shown in the figure 1.2. However, according to latest statistic of the Algerian agency for the promotion and rational use of energy (APRUE) in 2015, this percentage varies from zone to others, the Zone 2 and 7 represent the context of this study (Semi-arid climate) include Tebessa city. Subsequently, Figure 1.3 shows the final energy consumption by 35% in transport sector, 16% industrial sector, 6% agricultural sector and 45% residential & office building sector as shown in Figure.1.3. The utilization creates 25% of the national CO_2 outflow as these measurements are liable to ascend over the later because of the developing interest for convenience in building sector (Sotehi, Chaker, Benamra, & Ramoul, 2015b). This major consumption level warrants a point by point comprehension of the building sector's consumption elements to formulate and guide the sector's energy consumption in the attainment to stimulate efficiency, conservation, technology implementation and energy source substituting such as to on-site renewable energy.

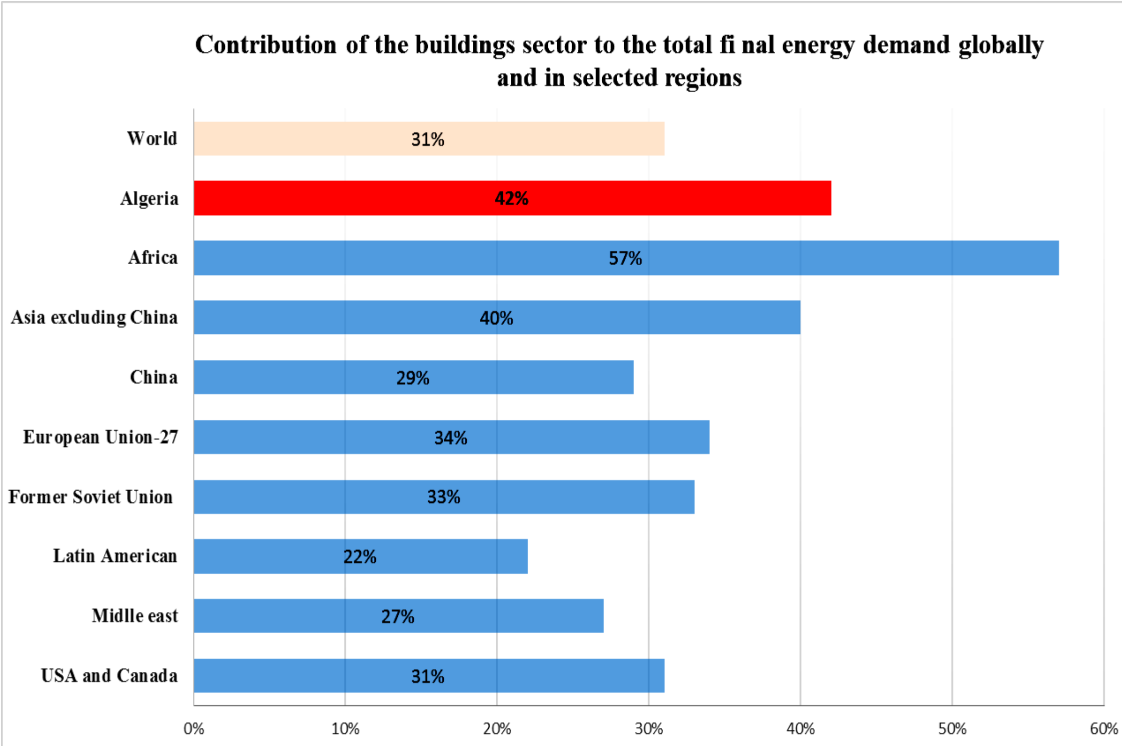


Figure 1.2: The average of building's energy consumption shown as a percentage of national energy consumption and in relative international form, Source: (IEA online

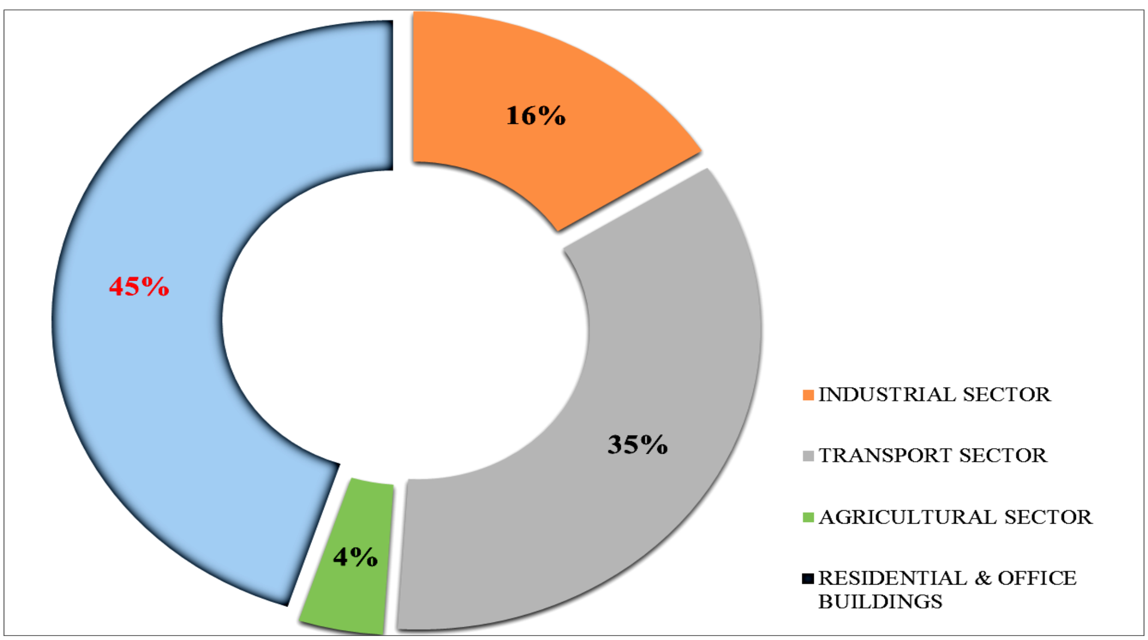


Figure 1.3: Final energy consumption by sector in Algeria -Zone 2. under semi-arid climate, Source: (APRUE, 2015).

The building sector is the largest consumer of energy, with a share of almost 50% of the entire energy consumption for all types of buildings, according to experts at Bayer, the German company that facilitated a meeting on the topic of energy efficiency on 29 May 2012 (the German-Algerian Chamber of Commerce). Approximately, 60% to 80% of this energy is lost. Up to 60% of the energy loss is attributed to air-conditioning and heating acquired through external envelopes (openings, roofs, walls and grounds). This percentage is in line with a recent study carried out by Missoum and Draoui in (2016). According to an APRUE report in 2013, the demand for electricity in Algeria has been increasing at a normal rate of 9.5% over the past five years, with 42% of the energy consumption being accounted for by residential and offices buildings, where 58% of the energy is from gas and 61% from electricity. According to studies by Bélaïd and Abderrahmani in (2013), electricity production is estimated to double in the next decade in order to maintain the economic growth and demographic expansion. On the other hand, a vital portion of the energy consumption in the building sector is marked by a solid annual growth rate of 6.28%, thereby making it necessary to consider energy saving measures (Ferhat & Boutrahi, 2014).

From another perspective, a study showed that there are no building regulations or any recommendations for daylighting and window-to-wall ratios (WWR) for public buildings. Thus, poor window designs and the absence of regulations in Algeria will lead to higher energy consumption (A. Belakehal, 2014). However, electric lighting now makes up 25% of the total energy consumption, making it one of the main consumers of electricity in buildings (Amirat & El Hassar, 2005).

There are concerns about the incorporation of PV on buildings, as the experience of various disadvantages has prevented the building sector from understanding the capability of this advancement in Algeria's building envelope. The main problems blocking improvements in solar technology have been identified as being in relation to financial issues, the extremely high cost of equipment and the time taken for returns on the capital invested for such innovations. In addition, householders are not interested in enhancing their energy efficiency by installing building-integrated photovoltaics (BIPV) in their homes to keep energy costs low. According to (Maafi, 2000; Semache, Hamidat, & Benchatti), and the APRUE report (2010), PV power is used for rural electrification, pumping, telecommunication repeaters, refrigeration and ventilation. The report published in APRUE (2010) by the European Commission on the 6^{th} framework program on research uncovered the deficiency of the policy regarding building-integrated PVs, while construction grants for both public and private buildings do not include any regulations with regard to the utilization of energy by buildings in this country. The awareness and doubts of households with regard to the installation of photovoltaics in residential buildings also need to be considered. In addition, studies by (Chaurey & Kandpal, 2010; Haw, Sopian, & Sulaiman, 2009) have stated that these are some of the fundamental limitations that need more attention in most countries as with other concerns arising from limitations in the system design (Heinstein, Ballif, & Perret-Aebi, 2013). In particular, these new technologies, such as BIPV systems (Goh, Goh, Yap, Masrom, & Mohamed, 2017; R. J. Yang & Zou, 2016), which can substitute historical building elements and can achieve additional purposes needed for the building's envelope (Maturi, 2013). Lately, it has been popular to produce electrical energy from windows and glass (Li, Lam, Chan, & Mak, 2009). This has been made possible by employing photovoltaic (PV) panels combined within windows. Such technology is created to aid several functions. In addition to the basic task of generating electricity, the multiple-use of BIPV window indicates that it is able to give glare protection and reduce heat gain and loss to save energy (Attoye, Tabet Aoul, & Hassan, 2017). However, there are insufficient researches and analyses in this domain, thereby making the development of this technology an urgent task in Algeria.

1.2 Problem Statement

In Algeria, the energy consumption levels for buildings are very high. A large amount of this energy is lost through the external envelope façade of buildings (claddings, openings), while energy demands for both heating and cooling are high in summer and winter respectively due to the nature of the Algerian climate. Since mid-rise buildings (4-11story) are the dominant typology in Algeria (Senouci et al., 2012), it has been suggested that window glazing should play a significant role as a building material, for which BIPV windows can be an alternative.

It has been noticed that literature exhibited a significant lack of BIPV windows energy support and performance in Algerian building sector (Maafi, 2000; A Boudghene Stambouli et al., 2012). Besides, the integration of BIPV windows into the façade of mid-rise buildings instead of conventional windows is almost non-existent as shown in figure 1.4, even though Algeria has an enormous potential in solar energy in addition to an obvious drop in PV prices in the market over the last few years.

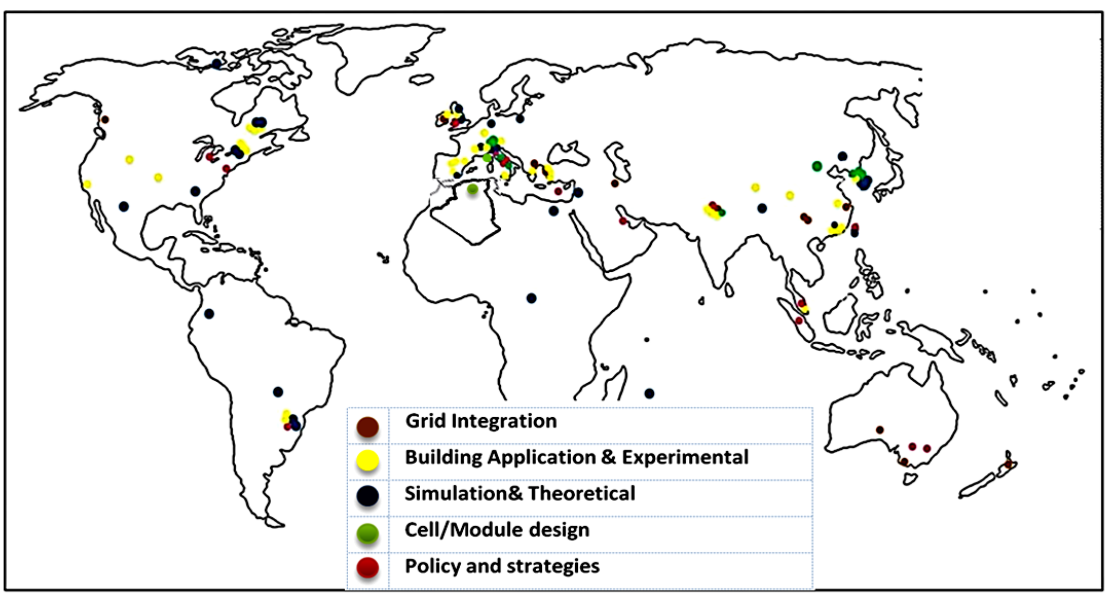


Figure 1.4: The Application of BIPV window technology in the world, Source: (Biyik et al., 2017)

The on-going research into energy consumption in the building sector in Algeria is mainly concentrated on several areas including the output efficiency of PV plants that are connected to an installed grid. This application was implemented on the site of the Centre for Development of Renewable Energy in Bouzaréah (Algiers) (Cherfaa et al.). This technology is considered to be the first of its kind in Algeria. In addition, the research has also been focused on minimising energy consumption by utilizing thermal insulation technology. The most common application is the usage of adobe (mud bricks) building material. Other techniques that have been given extensive importance in researches and practical applications in Algeria are the application of BIPVT systems (Sotehi, Chaker, Benamra, & Ramoul, 2015a) and the manipulation of the orientation of the building or natural ventilation in summer to obtain optimum performance (Hacene & Sari, 2013; Zemmouri & Schiler, 2005).

For all the reasons mentioned above, this research attempted to make use of the enormous solar energy potential of Algeria by utilizing the BIPV windows technology. This aim was accomplished by investigating the optimum performance of BIPV windows as an alternative solution for minimizing energy consumption in the building sector. The outcome of this research, if implemented, will positively impact energy savings for the occupants and beneficiaries of office buildings, as they comprise the most common category of energy consumers.

1.3 Research Gap

Architectural practices in Algeria generally do not keep pace with the use of the aspects of sustainability and technology to reduce energy in the building sector. Based on the literature and the observations of this researcher as an architect, the use of renewable solar energy panels in buildings is limited, except for those installed on the roofs of a few houses. The installation of BIPV windows in the vertical façade of mid-rise buildings is completely scarce even though the use of BIPV windows is linked with the huge vertical façade areas compared to roof areas. The solar radiation supplied by the vertical installations might not be at a maximum, but the energy savings could be compensated by the use of a huge façade such as in mid-rise and high-rise buildings. The majority of the studies that focused on the overall energy performance of BIPV windows targeted the climate of Asian countries, while no study has been performed in countries with a similar climate to Algeria. Consequently, in order to fill the gap, this research targeted the overall energy performance of BIPV windows in relation to the WWR, and the orientation and tilt angles in terms of four factors: visual comfort with energy output, utilization of day lighting, and heat gain and loss to achieve the optimum performance of a BIPV window façade in a semi-arid climate.

1.4 Research Aims

This research was aimed in determining the optimum performance of BIPV windows in a typical office building while maximizing daylighting and minimizing the heat gain/ heat loss into the interior in order to obtain a visually comfortable internal micro climate and energy savings in a semi-arid climate.

1.5 Research Objective

1. To investigate a level of the overall energy (Energy output, Heat gain/loss and Daylighting) of BIPV windows performance of a typical office building under Semi-arid climate in Algeria.
2. To evaluate the performance of different BIPV windows types based on (conversion Efficiency, visible Transparency, Solar Heat gain Coefficient

SHGC and U-value) orientations, Window to Wall Ratio (WWR) for assessment of overall energy use.

   a. To determine the optimum tilt angle design of BIPV window in term of energy output.
   b. To compare the overall energy performance of base-model with different BIPV window modules

3. To recommend an optimum design model of BIPV windows in cardinal orientations to improve energy saving and visual comfort in Algeria.

1.6 Research Questions

After reviewing the past literature, and in line with the above-mentioned objectives, this study will seek answers to the following research questions:

1. What are the influences of applying BIPV windows technology on overall energy performance under a Semi-arid climate of Algeria?
2. Does modifying the configuration of BIPV windows design (Orientations, types of PV, WWR) affect reducing the quantity of energy output?
3. What is the optimum tilt angle to maximise the energy output?
4. What is the optimum WWR and orientation of BIPV windows modules according to Algeria climate in the office buildings in view to optimise day lighting and maximise energy output?
5. Is it possible that the use of BIPV window as an alternative to conventional window could lead to zero energy saving?

1.7 Scope of the Study

The scope of this study covered the following points:

i. Building sector, including residential and public buildings, which is comprised of different activities such as for tourism (hotels, restaurants), education, health, administration, offices (financial institutions and other private services). However, this study focused on office buildings.

ii. Office building structures contain many spaces such as individual or open offices, laboratories, meeting rooms, and conference rooms. An individual office was chosen for this study because it is considered to be the most important element in an office building; however, a computer used as (electrical equipment) always has constant energy consumption for all scenarios.

iii. This study focused on second-generation PV modules (thin film technology) that are available in the market rather than on first-generation modules (silicon wafer-based technology).

iv. Algeria is a large country with four different climatic zones. The overall energy performance analysis of this study was limited to the Haut-plateau region of Algeria, where the majority of the offices are concentrated (the region is located between latitudes 34°-36° and is within a semi-arid climate zone).

v. This study focused on the effect on the overall energy performance of a BIPV window installed on the vertical façade rather than on the roof area of a building mainly because the roof area is relatively small compared to the external façade of a high-rise and mid-rise building. Furthermore, a large portion of the roof area is usually occupied by various building service installations such as water tanks, chillers, cooling towers, a lift machine room, etc.

vi. The EnergyPlus and IES-VE (Integration Environment Solution Virtual Environment) simulation software were chosen from several simulation software, including Design-builder, Ecotec, Velux, and Revit. Energy-Plus was chosen for its ability to simulate the BIPV window application accurately and to provide all the necessary details. At the same time, IES-VE was selected for its many properties and its accurate annual calculation of daylight through the WPI data, useful daylight illuminates and glare index metrics, and diminished light control (IES, 1993; IES-VE. 2006;(CF Reinhart & Breton, 2009).

1.8 Significance of the Research

There is no specific design of BIPV window in Algerian office buildings in relation to its orientation, sunlight permissible in office, and visual comfort of occupant through regulations to achieve the maximum energy saving and environmental needs. The Authorities of Algeria has not put in place a proper design procedure for office building energy consumption and visual comfort for users. Therefore, this research aims to generate significant information to serve as a platform for overall energy performance requirements for office building design. Subsequently, the requirements would form a basis for future overall energy and visual comfort recommendations for Algerian office building design.

1.9 Organisation of Thesis

Chapter Two reviews the state-of-the-art BIPV technology in the world and, particularly, in Algeria. This is followed by an explanation on the concept of the BIPV window and its classification and design. Furthermore, this chapter presents the electrical, climatic and architectural factors that influence the performance of the BIPV window technology. In addition, it reviews the experimental applications and heat transfer model of the BIPV window. It also provides an explanation of the visual comfort in offices and the metrics used to evaluate the quantity and quality of day lighting using the BIPV window. Furthermore, this chapter presents the performance of the BIPV window within an office building. It concludes with an examination of the relevant researches on this topic.

Chapter Three explains the research methodology, which is a combination of two methods. The first consists of a site visitation and experimental measurements in a selected Algerian office building, followed by computer simulations using EnergyPlus and IES-VE Integrated Environment Solution Virtual Environment.

Chapter Four presents the results of the field measurements in a tested office in Tebessa during critical time periods, and compares these results with the international standard. This chapter also presents the results from a simulated overall energy model of a base model and different BIPV window modules in the office in order to determine the maximum energy saved and to meet the criteria of visual comfort.

Chapter Five reviews the research objectives highlighted in Chapter one and examines the impact of the findings revealed through the outlined objectives. The practical implications and recommendations are highlighted, and the limitations of the study are discussed, with suggestions offered for further research.

REFERENCES

A. Belakehal, A. B. a. K. A. (2014). Office Buildings Daylighting Design in Hot Arid Regions: Forms, Codes and Occupants' Point of View. International Engineering Conference on Hot Arid Regions (IECHAR 2010).

Abdeladim, K., Bouchakour, S., Arab, A. H., Cherfa, F., Chouder, A., & Kerkouche, K. Contribution for assessment and mapping in Algeria using appropriate models

Abdelhakeem, M., Aminu, D. Y., & Kandar, M. Z. (2015). Investigating use of daylight in a typical algerian public classroom typology. JURNAL TEKNOLOGI, 77(15), 21-30.

Alexandri, E., Papastefanakis, D., & Damasiotis, M. (2008). Integration of solar technologies into buildings in Mediterranean communities. Centre for Renewable Energy Sources, Athens.

Alonso-Garcia, M., Ruiz, J., & Chenlo, F. (2006). Experimental study of mismatch and shading effects in the I–V characteristic of a photovoltaic module. Solar Energy Materials and Solar Cells, 90(3), 329-340.

Amar, H.-A. (2015). Quantification of solar radiation in Algeria, application to the sizing of photovoltaic systems. Université de Tlemcen.

Amirat, M., & El Hassar, S. (2005). Economies d'energie dans le secteur de l'habitat consommation electrique des ménages: Cas d'un foyer algérien typique en période d'hiver. Revue des énergies renouvelables, 8(1), 27-37.

Andenæs, E., Jelle, B. P., Ramlo, K., Kolås, T., Selj, J., & Foss, S. E. (2018). The influence of snow and ice coverage on the energy generation from photovoltaic solar cells. Solar Energy, 159, 318-328.

Andersen, D., & Foldbjerg, R. (2012). Daylight, Energy and Indoor Climate–Basic Book. Editorial team: Daylight Energy and Indoor Climate (DEIC), VELUX A/S.

Anderson, A.-L., Chen, S., Romero, L., Top, I., & Binions, R. (2016). Thin films for advanced glazing applications. Buildings, 6(3), 37.

APRUE. (2010). International Exhibition of Renewable Energy and Energy Management. Algeria: The National Agency for the Promotion and Rationalization of the Use of Energy Retrieved from http://www.aprue.org.dz/publications.html.

APRUE. (2015). Regional energy situation. Retrieved 10-9-2018, from The National Agency for the Promotion and Rationalization of the Use of Energy http://www.aprue.org.dz/publications.html

Aries, M. B., Veitch, J. A., & Newsham, G. R. (2010). Windows, view, and office characteristics predict physical and psychological discomfort. Journal of Environmental Psychology, 30(4), 533-541.

Aristizabal, A., & Gordillo, G. (2008). Performance monitoring results of the first grid-connected BIPV system in Colombia. Renewable Energy, 33(11), 2475-2484.

Attoye, D. E., Tabet Aoul, K. A., & Hassan, A. (2017). A Review on Building Integrated Photovoltaic Façade Customization Potentials. Sustainability, 9(12), 2287.

Barman, S., Chowdhury, A., Mathur, S., & Mathur, J. (2018). Assessment of the efficiency of window integrated CdTe based semi-transparent photovoltaic module. Sustainable Cities and Society, 37, 250-262.

Basak, O. D., & Sazak, B. S. (2013). Effect of developments on a PV system efficiency. Paper presented at the Electrical and Electronics Engineering (ISEEE), 2013 4th International Symposium on.

Bayrak, F., Ertürk, G., & Oztop, H. F. (2017). Effects of partial shading on energy and exergy efficiencies for photovoltaic panels. Journal of cleaner production, 164, 58-69.

Bélaïd, F., & Abderrahmani, F. (2013). Electricity consumption and economic growth in Algeria: A multivariate causality analysis in the presence of structural change. Energy Policy, 55, 286-295.

Bellia, L., Cesarano, A., Iuliano, G. F., & Spada, G. (2008). Daylight glare: a review of discomfort indexes.

Bellini, E. (2017). Aurés Solaire commissions Algeria’s second module factory. PV magazine.

Bellini, E. (2018). Engie, Sonatrach officialize partnership for solar and renewables. PV magazine.

Bendel, C. (2003). Multifunktionale Nutzung photovoltaischer Anlagen. Photovoltaik–Neue Horizonte, 76.

Biyik, E., Araz, M., Hepbasli, A., Shahrestani, M., Yao, R., Shao, L., . . . Rico, E. (2017). A key review of building integrated photovoltaic (BIPV) systems. Engineering science and technology, an international journal, 20(3), 833-858.

Cantin, F., & Dubois, M.-C. (2011). Daylighting metrics based on illuminance, distribution, glare and directivity. Lighting Research & Technology, 43(3), 291-307.

Carlos, J. S., & Corvacho, H. (2015). Evaluation of the performance indices of a ventilated double window through experimental and analytical procedures: SHGC-values. Energy and Buildings, 86, 886-897.

Carlucci, S., Causone, F., De Rosa, F., & Pagliano, L. (2015). A review of indices for assessing visual comfort with a view to their use in optimization processes to support building integrated design. Renewable and Sustainable Energy Reviews, 47, 1016-1033.

CDER. (2016). Photovoltaic solar energy Division Retrieved 03-28-2016, 2016, from http://www.cder.dz/spip.php?rubrique213

Chaurey, A., & Kandpal, T. C. (2010). Assessment and evaluation of PV based decentralized rural electrification: An overview. Renewable and Sustainable Energy Reviews, 14(8), 2266-2278.

Chegaar, M., & Chibani, A. (2001). Global solar radiation estimation in Algeria. Energy conversion and management, 42(8), 967-973.

Chen, F., Wittkopf, S. K., Ng, P. K., & Du, H. (2012). Solar heat gain coefficient measurement of semi-transparent photovoltaic modules with indoor calorimetric hot box and solar simulator. Energy and Buildings, 53, 74-84.

Chen, W., Shen, H., & Liu, Y. (2009). Performance evaluation of PV arrays at different tilt angles and orientations in BIPV. Taiyangneng Xuebao. Acta Energiae Solaris Sinica, 30, 206-210.

Cherfaa, F., Araba, A. H., Oussaidb, R., Abdeladima, K., Bouchakoura, S., & Kerkouchea, K. Performance evaluation of the first grid connected PV system in Algeria. Paper presented at the 28th European Photovoltaic Solar Energy Conference and Exhibition. Paris.

Chiang, C.-M., & Lai, C.-M. (2002). A study on the comprehensive indicator of indoor environment assessment for occupants' health in Taiwan. Building and Environment, 37(4), 387-392.

Commission, C. o. t. E. (2010). Directive 2010/31/EU of the European Parliament and of the council of 19 May 2010 on the energy performance of buildings. Off. J. Eur. Union L, 153, 13-35.

Cornaro, C., Basciano, G., Puggioni, V. A., & Pierro, M. (2017). Energy saving assessment of semi-transparent photovoltaic modules integrated into NZEB. Buildings, 7(1), 9.

Corporation, O. C. (2009). HOBO Pendant,Temperature/Light Data Logger: Specifications and Light measurement

Retrieved 01-03-2015 www.onsetcomp.com

Crawley, D. B., Hand, J. W., Kummert, M., & Griffith, B. T. (2008). Contrasting the capabilities of building energy performance simulation programs. Building and Environment, 43(4), 661-673.

Cuce, E. (2016). Toward multi-functional PV glazing technologies in low/zero carbon buildings: Heat insulation solar glass–Latest developments and future prospects. Renewable and Sustainable Energy Reviews, 60, 1286-1301.

De Carli, M., De Giuli, V., & Zecchin, R. (2008). Review on visual comfort in office buildings and influence of daylight in productivity. Paper presented at the 11th International Conference Indoor Air, Copenhagen.

Didoné, E. L., & Wagner, A. (2013). Semi-transparent PV windows: a study for office buildings in Brazil. Energy and Buildings, 67, 136-142.

Dinçer, İ., Midilli, A., & Kucuk, H. (2014). Progress in Sustainable Energy Technologies: Generating Renewable Energy (Vol. 1): Springer.

Djalel, D., & Moatezbillah, G. (2014). Optimal Exploitation of a Solar Power System for a Semi-Arid Zone (Case Study: Ferkène, Algeria). International Journal of Renewable Energy Research (IJRER), 4(2), 389-400.

Djamel, Z., & Noureddine, Z. (2017). The Impact of Window Configuration on the Overall Building Energy Consumption under Specific Climate Conditions. Energy Procedia, 115, 162-172. doi: https://doi.org/10.1016/j.egypro.2017.05.016

Dubey, S., Sarvaiya, J. N., & Seshadri, B. (2013). Temperature dependent photovoltaic (PV) efficiency and its effect on PV production in the world–a review. Energy Procedia, 33, 311-321.

Duffie, J. A., & Beckman, W. A. (2013). Solar engineering of thermal processes: John Wiley & Sons.

Eiffert, P., & Kiss, G. J. (2000). Building-integrated photovoltaic designs for commercial and institutional structures: a sourcebook for architects: DIANE Publishing.

Ellis, P. G., Torcellini, P. A., & Crawley, D. B. (2008). Energy Design Plugin: An EnergyPlus Plugin for SketchUp; Preprint: National Renewable Energy Lab.(NREL), Golden, CO (United States).

Falk, A., Durschner, C., & Remmers, K.-H. (2013). Photovoltaics for professionals: solar electric systems marketing, design and installation: Routledge.

Fedail, H. H. A. (2015). Design and Implementation of a Microcontroller–Based Solar Panel Tracking System. Sudan University of Science and Technology.

Ferhat, S., & Boutrahi, M. (2014). The Residential Built Heritage Of Algiers And Its Energy Behaviour: Case Study Of The Building Number 3 Flats Of The Aero-habitat District. WIT Transactions on Ecology and the Environment, 186, 39-53.

Fesharaki, V. J., Dehghani, M., Fesharaki, J. J., & Tavasoli, H. (2011). The effect of temperature on photovoltaic cell efficiency. Paper presented at the Proceedings of the 1stInternational Conference on Emerging Trends in Energy Conservation–ETEC, Tehran, Iran.

Flodberg, K., Blomsterberg, Å., & Dubois, M.-C. (2012). Low-energy office buildings using existing technology: simulations with low internal heat gains. International Journal of Energy and Environmental Engineering, 3(1), 19.

Fung, T. Y., & Yang, H. (2008). Study on thermal performance of semi-transparent building-integrated photovoltaic glazings. Energy and Buildings, 40(3), 341-350.

Gairaa, K., & Bakelli, Y. (2013). Solar energy potential assessment in the Algerian south area: case of Ghardaïa region. Journal of Renewable Energy, 2013.

Gassim, O. A. O. (2015). Improvement of Performance of Conjugated Polymer Solar Cells Coated. Sudan University of Science and Technology.

Geoff Stapleton, S. N., Geoff Milne (2013). Photovoltaic systems. Retrieved 9/2/2018 http://www.yourhome.gov.au

Ghezloun, A., Oucher, N., & Chergui, S. (2012). Energy policy in the context of sustainable development: Case of Algeria and Tunisia. Energy Procedia, 18, 53-60.

Goel, S., Rosenberg, M. I., & Eley, C. (2017). ANSI/ASHRAE/IES Standard 90.1-2016 Performance Rating Method Reference Manual: Pacific Northwest National Lab.(PNNL), Richland, WA (United States).

Goh, K. C., Goh, H. H., Yap, A. B. K., Masrom, M. A. N., & Mohamed, S. (2017). Barriers and drivers of Malaysian BIPV application: Perspective of developers. Procedia Eng, 180, 1585-1595.

Green, M. A. (2003). Crystalline and thin-film silicon solar cells: state of the art and future potential. Solar Energy, 74(3), 181-192.

Green, M. A., Emery, K., Hishikawa, Y., Warta, W., & Dunlop, E. D. (2015). Solar cell efficiency tables (Version 45). Progress in Photovoltaics: Research and applications, 23(1), 1-9.

Griffith, B. T., & Ellis, P. G. (2004). Photovoltaic and Solar Thermal Modeling with the EnergyPlus Calculation Engine: Preprint: National Renewable Energy Lab., Golden, CO (US).

Grynning, S., Gustavsen, A., Time, B., & Jelle, B. P. (2013). Windows in the buildings of tomorrow: Energy losers or energy gainers? Energy and Buildings, 61, 185-192.

Gulagi, A. (2015). Characterization and Investigation on Material Compatibilities of Building Integrated Photovoltaic Module Components.

Hacene, M. E. A. B., & Sari, N. E. C. (2013). Algerian Strategy in the Context of Sustainable Development: The Case of Green Building. Int. J. of Thermal & Environmental Engineering, 6(1), 1-6.

Hachem, C., Fazio, P., & Athienitis, A. (2013). Solar optimized residential neighborhoods: Evaluation and design methodology. Solar Energy, 95, 42-64.

Hamakawa, Y. (2013). Thin-film solar cells: next generation photovoltaics and its applications (Vol. 13): Springer Science & Business Media.

Hammad, B., Al–Abed, M., Al–Ghandoor, A., Al–Sardeah, A., & Al–Bashir, A. (2017). Modeling and analysis of dust and temperature effects on photovoltaic systems' performance and optimal cleaning frequency: Jordan case study. Renewable and Sustainable Energy Reviews.

Han, J., Lu, L., Peng, J., & Yang, H. (2013). Performance of ventilated double-sided PV façade compared with conventional clear glass façade. Energy and Buildings, 56, 204-209.

Han, J., Lu, L., & Yang, H. (2009). Thermal behavior of a novel type see-through glazing system with integrated PV cells. Building and Environment, 44(10), 2129-2136.

Haselbach, L. (2008). The engineering guide to LEED-new construction: sustainable construction for engineers: McGraw-Hill.

Haw, L., Sopian, K., & Sulaiman, Y. (2009). Public response to residential building integrated photovoltaic system (BIPV) in Kuala Lumpur urban area. Paper presented at the Proceedings of the 4th IASME/WSEAS International Conference on Energy and Environment, Cambridge, UK.

Haysom, J. E., Hinzer, K., & Wright, D. (2016). Impact of electricity tariffs on optimal orientation of photovoltaic modules. Progress in Photovoltaics: Research and applications, 24(2), 253-260.

He, W., Zhang, Y., Sun, W., Hou, J., Jiang, Q., & Ji, J. (2011). Experimental and numerical investigation on the performance of amorphous silicon photovoltaics window in East China. Building and Environment, 46(2), 363-369.

Heinstein, P., Ballif, C., & Perret-Aebi, L.-E. (2013). Building integrated photovoltaics (BIPV): review, potentials, barriers and myths. Green, 3(2), 125-156.

Hensen, J. L., & Lamberts, R. (2012). Building performance simulation for design and operation: Routledge.

Henson, J. W. C. (2012). BIPV FAÇADES RECONSIDERED: MID-RISE AND HIGH RISE APPLICATIONS. Paper presented at the Building Enclosure Science & Technology (BEST3) Conference.

Hepbasli, A. (2008). A key review on exergetic analysis and assessment of renewable energy resources for a sustainable future. Renewable and Sustainable Energy Reviews, 12(3), 593-661.

Himri, Y., Malik, A. S., Stambouli, A. B., Himri, S., & Draoui, B. (2009). Review and use of the Algerian renewable energy for sustainable development. Renewable and Sustainable Energy Reviews, 13(6), 1584-1591.

Hui, S. C. (1997). From renewable energy to sustainability: the challenge for Hong Kong. Hong Kong Institution of Engineers, 351-358.

Huijts, N. M., Molin, E., & Steg, L. (2012). Psychological factors influencing sustainable energy technology acceptance: A review-based comprehensive framework. Renewable and Sustainable Energy Reviews, 16(1), 525-531.

Husnaina, I., Mushtaqa, W., & Khana, Z. S. (2016). Comparison of thin film versus crystalline PV modules for utility-scale electric power production in Pakistan.

Ibarra, D., & Reinhart, C. F. (2009). Daylight factor simulations–how close do simulation beginners ‘really’get? Paper presented at the Building simulation.

IEA. (2013). World Energy Resources Survey. 468. www.worldenergy.org

Ihm, P., Nemri, A., & Krarti, M. (2009). Estimation of lighting energy savings from daylighting. Building and Environment, 44(3), 509-514.

Index, G. B., & Malaysia, G. (2013). Green Building Index: Retrieved.

Infield, D., Eicker, U., Fux, V., Mei, L., & Schumacher, J. (2006). A simplified approach to thermal performance calculation for building integrated mechanically ventilated PV facades. Building and Environment, 41(7), 893-901.

Intissar Fakir, D. g.-y. (2016). Running Low: Algeria’s Fiscal Challenges and Implications for Stability. http://carnegie-mec.org/2016/02/11/running-low-algeria-s-fiscal-challenges-and-implications-for-stability/itu8

ISO, I. (2002). 8995-1: 2002 (CIE S 008/E: 2001). Lighting of indoor work places. Geneva: ISO Organización Internacional de Normalización.

Jakubiec, J., & Reinhart, C. (2011). DIVA-FOR-RHINO 2.0: Environmental parametric modeling in Rhinoceros/Grasshopper using RADIANCE, Daysim and EnergyPlus. Paper presented at the Conference proceedings of building simulation.

Jarić, M., Budimir, N., Pejanovic, M., & Svetel, I. (2013). A review of energy analysis simulation tools.

Kacira, M., Simsek, M., Babur, Y., & Demirkol, S. (2004). Determining optimum tilt angles and orientations of photovoltaic panels in Sanliurfa, Turkey. Renewable Energy, 29(8), 1265-1275.

Kapsis, K., & Athienitis, A. K. (2011). Building integrated semi-transparent photovoltaics: energy and daylighting performance. Paper presented at the Photonics North 2011.

Kapsis, K., Dermardiros, V., & Athienitis, A. (2015). Daylight performance of perimeter office façades utilizing semi-transparent photovoltaic windows: a simulation study. Energy Procedia, 78, 334-339.

Kazem, H. A., Chaichan, M. T., Alwaeli, A. H., & Mani, K. (2017). Effect of Shadows on the Performance of Solar Photovoltaic, Cham.

Khatib, T., Kazem, H., Sopian, K., Buttinger, F., Elmenreich, W., & Albusaidi, A. S. (2013). Effect of dust deposition on the performance of multi-crystalline photovoltaic modules based on experimental measurements. International Journal of Renewable Energy Research (IJRER), 3(4), 850-853.

Kibria, M. T., Ahammed, A., Sony, S., Hossain, F., & Islam, S. (2014). A Review: Comparative studies on different generation solar cells technology. Paper presented at the Proc. of 5th International Conference on Environmental Aspects of Bangladesh.

Krarti, M., Erickson, P. M., & Hillman, T. C. (2005). A simplified method to estimate energy savings of artificial lighting use from daylighting. Building and Environment, 40(6), 747-754.

Kurayama, C. (2006). Developement of a Measurement Sysem for SHGC and U-VALUE: Study on SHGC and U-value for fenestration and shading system Part 1. Journal of Environmental Engineering (Transactions of AIJ), 71(604), 15-22.

Lam, T., Ge, H., & Fazio, P. (2016). Energy positive curtain wall configurations for a cold climate using the Analysis of Variance (ANOVA) approach. Paper presented at the Building Simulation.

Laura Maturi, J. A. (2018). Building Integrated Photovoltaic In Trentino Alto Adige Springer International PU.

Lee, T. D., & Ebong, A. U. (2017). A review of thin film solar cell technologies and challenges. Renewable and Sustainable Energy Reviews, 70, 1286-1297.

Li, D. H. (2010). A review of daylight illuminance determinations and energy implications. Applied Energy, 87(7), 2109-2118.

Li, D. H., Lam, T. N., Chan, W. W., & Mak, A. H. (2009). Energy and cost analysis of semi-transparent photovoltaic in office buildings. Applied Energy, 86(5), 722-729.

Liao, W., & Xu, S. (2015). Energy performance comparison among see-through amorphous-silicon PV (photovoltaic) glazings and traditional glazings under different architectural conditions in China. Energy, 83, 267-275.

López, C. S. P., & Sangiorgi, M. (2014). Comparison assessment of BIPV façade semi-transparent modules: further insights on human comfort conditions. Energy Procedia, 48, 1419-1428.

Lu, L., & Law, K. M. (2013). Overall energy performance of semi-transparent single-glazed photovoltaic (PV) window for a typical office in Hong Kong. Renewable Energy, 49, 250-254.

Lu, L., & Yang, H. (2004). A study on simulations of the power output and practical models for building integrated photovoltaic systems. Journal of Solar Energy Engineering, 126(3), 929-935.

Luo, Y., Feng, Z., Han, Y., & Li, H. (2010). Design of compact and smooth free-form optical system with uniform illuminance for LED source. Optics express, 18(9), 9055-9063.

Maafi, A. (2000). A survey on photovoltaic activities in Algeria. Renewable Energy, 20(1), 9-17.

Mahato, N., Ansari, M. O., & Cho, M. H. (2015). Production of Utilizable Energy from Renewable Resources: Mechanism, Machinery and Effect on Environment. Paper presented at the Advanced Materials Research.

Maile, T., Fischer, M., & Bazjanac, V. (2007). Building energy performance simulation tools-a life-cycle and interoperable perspective.

Mardaljevic, J., Andersen, M., Roy, N., & Christoffersen, J. (2012). Daylighting metrics: is there a relation between useful daylight illuminance and daylight glare probability. Paper presented at the Proceedings of the building simulation and optimization conference (BSO12), Loughborough, UK.

Maturi, L. (2013). Building skin as energy supply: Prototype development of a wooden prefabricated BiPV wall. University of Trento.

Maurus, H., Schmid, M., Blersch, B., Lechner, P., & Schade, H. (2004). PV for buildings: benefits and experiences with amorphous silicon in BIPV applications. Refocus, 5(6), 22-27.

McCluney, R. (1991). The death of the shading coefficient. ASHRAE journal, 33(3), 36-45.

McNeil, A., & Burrell, G. (2016). Applicability of DGP and DGI for evaluating glare in a brightly daylit space. Proceedings of SimBuild, 6(1).

Mehleri, E., Zervas, P., Sarimveis, H., Palyvos, J., & Markatos, N. (2010). Determination of the optimal tilt angle and orientation for solar photovoltaic arrays. Renewable Energy, 35(11), 2468-2475.

Meral, M. E., & Dinçer, F. (2011). A review of the factors affecting operation and efficiency of photovoltaic based electricity generation systems. Renewable and Sustainable Energy Reviews, 15(5), 2176-2184.

Missoum, A., Elmir, M., Bouanini, M., & Draoui, B. (2016). Numerical simulation of heat transfer through the building facades of buildings located in the city of Bechar. International Journal of Multiphysics, 10(4).

Miyazaki, T., Akisawa, A., & Kashiwagi, T. (2005). Energy savings of office buildings by the use of semi-transparent solar cells for windows. Renewable Energy, 30(3), 281-304.

Mondol, J. D., Yohanis, Y. G., & Norton, B. (2007). The impact of array inclination and orientation on the performance of a grid-connected photovoltaic system. Renewable Energy, 32(1), 118-140.

Montoro, D., Vanbuggenhout, P., & Ciesielska, J. (2011). Building Integrated Photovoltaics: An overview of the existing products and their fields of application. Report Prepared in the Framework of the European Funded Project; SUNRISE: Saskatoon, Canada.

Moscoso, C. P. (2016). Daylighting and Architectural Quality: Aesthetic Perception of Daylit Indoor Environments.

Motuziene, V., & Juodis, E. S. (2010). Simulation based complex energy assessment of office building fenestration. Journal of civil Engineering and management, 16(3), 345-351.

Motuziene, V., & Valancius, K. (2015). Multi-criteria assesment of building integrated photovoltaics. Mokslas: Lietuvos Ateitis, 7(4), 499.

Mousavi, S. M., Khan, T. H., & Lim, Y.-W. (2018). Impact of Furniture Layout on Indoor Daylighting Performance in Existing Residential Buildings in Malaysia. Journal of Daylighting, 5(1), 1-13.

Nabil, A., & Mardaljevic, J. (2005). Useful daylight illuminance: a new paradigm for assessing daylight in buildings. Lighting Research & Technology, 37(1), 41-57.

Nabil, A., & Mardaljevic, J. (2006). Useful daylight illuminances: A replacement for daylight factors. Energy and Buildings, 38(7), 905-913.

Ng, P. K., Mithraratne, N., & Kua, H. W. (2013). Energy analysis of semi-transparent BIPV in Singapore buildings. Energy and Buildings, 66, 274-281.

Nikpour, M., Kandar, M., & Roshan, M. (2013). Empirical vof IES< VE> simulation in term of daylight in self-shading office room in Malaysia. Journal of Basic Applied Science Research, 3(10), 106-112.

Nordmann, T., & Clavadetscher, L. (2003). Understanding temperature effects on PV system performance. Paper presented at the Photovoltaic Energy Conversion, 2003. Proceedings of 3rd World Conference on.

Norton, B., Eames, P. C., Mallick, T. K., Huang, M. J., McCormack, S. J., Mondol, J. D., & Yohanis, Y. G. (2011). Enhancing the performance of building integrated photovoltaics. Solar Energy, 85(8), 1629-1664.

Olivieri, L., Caamaño-Martín, E., Moralejo-Vázquez, F. J., Martín-Chivelet, N., Olivieri, F., & Neila-Gonzalez, F. (2014). Energy saving potential of semi-transparent photovoltaic elements for building integration. Energy, 76, 572-583.

Olivieri, L., Caamaño-Martin, E., Olivieri, F., & Neila, J. (2014). Integral energy performance characterization of semi-transparent photovoltaic elements for building integration under real operation conditions. Energy and Buildings, 68, 280-291.

Osman, M. M., & Alibaba, A. P. D. H. Z. (2015). Comparative Studies on Integration of Photovoltaic in Hot and Cold Climate.

Özakın, A., Karsli, S., Kaya, F., & Güllüce, H. (2016). The heat recovery with heat transfer methods from solar photovoltaic systems. Paper presented at the Journal of Physics: Conference Series.

Park, K.-W., & Athienitis, A. K. (2003). Workplane illuminance prediction method for daylighting control systems. Solar Energy, 75(4), 277-284.

Park, K., Kang, G., Kim, H., Yu, G., & Kim, J. (2010). Analysis of thermal and electrical performance of semi-transparent photovoltaic (PV) module. Energy, 35(6), 2681-2687.

Pasini, I. (2002). Daylighting Guide for Canadian Commercial Buildings. 86.

Paulescu, M., Paulescu, E., Gravila, P., & Badescu, V. (2012). Weather modeling and forecasting of PV systems operation: Springer Science & Business Media.

Peng, C., Huang, Y., & Wu, Z. (2011). Building-integrated photovoltaics (BIPV) in architectural design in China. Energy and Buildings, 43(12), 3592-3598.

Peng, J., Lu, L., Yang, H., & Ma, T. (2015a). Comparative study of the thermal and power performances of a semi-transparent photovoltaic façade under different ventilation modes. Applied Energy, 138, 572-583.

Peng, J., Lu, L., Yang, H., & Ma, T. (2015b). Validation of the Sandia model with indoor and outdoor measurements for semi-transparent amorphous silicon PV modules. Renewable Energy, 80, 316-323.

Pidwirny, M. (2014). Introduction to the Biosphere: Single chapter from the eBook Understanding Physical Geography: Our Planet Earth Publishing.

Rasul, M. G., & Doring, C. (2017). Performance Assessment of Desiccant air Conditioning System in an Institutional Building in Subtropical Climate. Energy Procedia, 110, 486-491.

Reinhart, C. (2011). Tutorial on the Use of Daysim Simulations for Sustainable Design, 2010. Harvard Design School.

Reinhart, C., & Breton, P.-F. (2009). Experimental validation of 3ds Max® Design 2009 and Daysim 3.0. Draft manuscript submitted to Building Simulation.

Reinhart, C., & Fitz, A. (2006). Findings from a survey on the current use of daylight simulations in building design. Energy and Buildings, 38(7), 824-835.

Reinhart, C. F., & Walkenhorst, O. (2001). Validation of dynamic RADIANCE-based daylight simulations for a test office with external blinds. Energy and Buildings, 33(7), 683-697.

Remund, J., Müller, S., Schilter, C., & Rihm, B. (2010). The use of Meteonorm weather generator for climate change studies. Paper presented at the 10th EMS Annual Meeting, 10th European Conference on Applications of Meteorology (ECAM) Abstracts, held Sept. 13-17, 2010 in Zürich, Switzerland. http://meetings. copernicus. org/ems2010/, id. EMS2010-417.

Remund, J., & Müller, S. C. (2011). Solar radiation and uncertainty information of Meteonorm 7. Paper presented at the Proceedings of 26th European Photovoltaic Solar Energy Conference and Exhibition.

Robertson, K. (2003). guide on daylighting of buildings. 24.

Robinson, L., & Athienitis, A. (2009). Design methodology for optimization of electricity generation and daylight utilization for façade with semi-transparent photovoltaics. Paper presented at the Proc. Building Simulation.

Rogers, J. C., Simmons, E. A., Convery, I., & Weatherall, A. (2008). Public perceptions of opportunities for community-based renewable energy projects. Energy Policy, 36(11), 4217-4226.

Rouag, D. S. (2001). Sunlight problems within new primary school classrooms in Constantine (Algeria). (PHD), University of Mentouri, Constantine -Algeria-.

Rustemli, S., & Dincer, F. (2011). Modeling of photovoltaic panel and examining effects of temperature in Matlab/Simulink. Elektronika ir Elektrotechnika, 109(3), 35-40.

Salem, T., & Kinab, E. (2015). Analysis of Building-integrated Photovoltaic Systems: A Case Study of Commercial Buildings under Mediterranean Climate. Procedia Engineering, 118, 538-545.

Sampaio, P. G. V., & González, M. O. A. (2017). Photovoltaic solar energy: Conceptual framework. Renewable and Sustainable Energy Reviews, 74, 590-601.

Sankaranarayanan, K., Van Der Kooi, H. J., & de Swaan Arons, J. (2010). Efficiency and sustainability in the energy and chemical industries: scientific principles and case studies: Crc Press.

Schoen, T., Prasad, D., Ruoss, D., Eiffert, P., & Sørensen, H. (2001). Task 7 of the IEA PV power systems program–achievements and outlook. Paper presented at the Proceedings of the 17th European Photovoltaic Solar Conference.

Scognamiglio, A., & Røstvik, H. N. (2013). Photovoltaics and zero energy buildings: a new opportunity and challenge for design. Progress in Photovoltaics: Research and applications, 21(6), 1319-1336.

Semache, A., Hamidat, A., & Benchatti, A. Impacts Study of The Solar Energy On The Energy Performance of The Rural Housing In Algeria

Senouci, A., Taibim, A., Nedjar, D., Ramdane, A., Farsi, M. N., Bard, P.-Y., . . . Cartier, S. (2012). Classification of buildings of Oran city (Algeria) based on their seismic vulnerability. Paper presented at the 15th World Conference on Earthquake Engineering.

Sfaelou, S., & Lianos, P. (2016). Photoactivated Fuel Cells (PhotoFuelCells). An alternative source of renewable energy with environmental benefits.

Shah, A. (2017). Thin-film silicon solar cells McEvoy's Handbook of Photovoltaics (Third Edition) (pp. 235-307): Elsevier.

Shaheen, S. E., Ginley, D. S., & Jabbour, G. E. (2005). Organic-based photovoltaics: toward low-cost power generation. MRS bulletin, 30(01), 10-19.

Simson, R., Kurnitski, J., & Kuusk, K. (2017). Experimental validation of simulation and measurement-based overheating assessment approaches for residential buildings. Architectural Science Review, 60(3), 192-204.

Siong, C. T., & Janssen, P. (2013). Semi-Transparent Building Integrated Photovoltaic Facades–Maximise Energy Savings Using Evolutionary Multi-Objective Optimisation.

Skandalos, N., & Karamanis, D. (2016). Investigation of thermal performance of semi-transparent PV technologies. Energy and Buildings, 124, 19-34.

Skoplaki, E., & Palyvos, J. A. (2009). On the temperature dependence of photovoltaic module electrical performance: A review of efficiency/power correlations. Solar Energy, 83(5), 614-624.

Song, J.-H., An, Y.-S., Kim, S.-G., Lee, S.-J., Yoon, J.-H., & Choung, Y.-K. (2008). Power output analysis of transparent thin-film module in building integrated photovoltaic system (BIPV). Energy and Buildings, 40(11), 2067-2075.

Sopian, K., Cheow, S., & Zaidi, S. (2017). An overview of crystalline silicon solar cell technology: Past, present, and future. Paper presented at the AIP Conference Proceedings.

Sotehi, O., Chaker, A., Benamra, M. L., & Ramoul, E. (2015a). Theoretical Investigation on a Building-Integrated PV/T (BiPVT) System for Electrical and Thermal Energy Saving Case Study: Integrated Solar Village of Bou Saada. In I. Dincer, O. C. Colpan, O. Kizilkan & A. M. Ezan (Eds.), Progress in Clean Energy, Volume 2: Novel Systems and Applications (pp. 433-448). Cham: Springer International Publishing.

Sotehi, O., Chaker, A., Benamra, M. L., & Ramoul, E. (2015b). Theoretical Investigation on a Building-Integrated PV/T (BiPVT) System for Electrical and Thermal Energy Saving Case Study: Integrated Solar Village of Bou Saada Progress in Clean Energy, Volume 2 (pp. 433-448): Springer.

Stambouli, A. B. (2011). Promotion of renewable energies in Algeria: strategies and perspectives. Renewable and Sustainable Energy Reviews, 15(2), 1169-1181.

Stambouli, A. B., Khiat, Z., Flazi, S., & Kitamura, Y. (2012). A review on the renewable energy development in Algeria: current perspective, energy scenario and sustainability issues. Renewable and Sustainable Energy Reviews, 16(7), 4445-4460.

Stoppato, A. (2008). Life cycle assessment of photovoltaic electricity generation. Energy, 33(2), 224-232.

Stouffs, R., Janssen, P., Roudavski, S., & Tunçer, B. (2013). Semi-transparent building integrated photovoltaic facades. Paper presented at the Conference on Computer-Aided Architectural Design Research in Asia (CAADRIA 2013).

Sun, L., Lu, L., & Yang, H. (2012). Optimum design of shading-type building-integrated photovoltaic claddings with different surface azimuth angles. Applied Energy, 90(1), 233-240.

Teske, S., Zervos, A., & Schäfer, O. (2007). Energy Revolution: A Sustainable World Energy Outlook: Greenpeace International and European Renewable Energy Council.

Verberne, G., Bonomo, P., Frontini, F., Donker, M., Chatzipanagi, A., Sinapis, K., & Folkerts, W. (2015). BIPV products for facades and roof: a market analysis. Solar Energy, 2014, 2013.

Vlek, C., & Steg, L. (2007). ⊡ Human Behavior and Environmental Sustainability: Problems, Driving Forces, and Research Topics. Journal of social issues, 63(1), 1-19.

Wah, W. P., Shimoda, Y., Nonaka, M., Inoue, M., & Mizuno, M. (2005). Field study and modeling of semi-transparent PV in power, thermal and optical aspects. Journal of Asian Architecture and Building Engineering, 4(2), 549-556.

Wang, C., Peng, J., Li, N., Wang, M., & Li, X. (2017). Study on the Operation Strategy of Ventilated Photovoltaic Windows in Hot-Summer and Cold-Winter Zone in China. Procedia Engineering, 205, 2092-2099.

Wang, M., Peng, J., Li, N., Lu, L., & Yang, H. (2017). Experimental Study on Thermal Performance of Semi-transparent PV Window in Winter in Hong Kong. Energy Procedia, 105, 864-868.

Wang, M., Peng, J., Li, N., Yang, H., Wang, C., Li, X., & Lu, T. (2017). Comparison of energy performance between PV double skin facades and PV insulating glass units. Applied Energy, 194, 148-160.

Wang, Y., Tian, W., Ren, J., Zhu, L., & Wang, Q. (2006). Influence of a building's integrated-photovoltaics on heating and cooling loads. Applied Energy, 83(9), 989-1003.

Watt, M. (2001). Added Values of Photovoltaic Power Systems, Report IEA - PVPS T1 - 09 : 2001. Australia

Weicht, J., Rasch, R., Behrens, G., & Hamelmann, F. (2016). Performance characterization of thin-film-silicon based solar modules under clouded and clear sky conditions in comparison to crystalline silicon modules. Electronic Materials Letters, 12(4), 468-471.

Wong, L. (2017). A review of daylighting design and implementation in buildings. Renewable and Sustainable Energy Reviews, 74, 959-968.

Wong, P. W., Shimoda, Y., Nonaka, M., Inoue, M., & Mizuno, M. (2008). Semi-transparent PV: Thermal performance, power generation, daylight modelling and energy saving potential in a residential application. Renewable Energy, 33(5), 1024-1036.

Wright, J. A., Brownlee, A., Mourshed, M. M., & Wang, M. (2014). Multi-objective optimization of cellular fenestration by an evolutionary algorithm. Journal of Building Performance Simulation, 7(1), 33-51.

Wüstenhagen, R., Wolsink, M., & Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. Energy Policy, 35(5), 2683-2691.

Xu, S., Liao, W., Huang, J., & Kang, J. (2014). Optimal PV cell coverage ratio for semi-transparent photovoltaics on office building façades in central China. Energy and Buildings, 77, 130-138.

Xue, G., Liu, K., Chen, Q., Yang, P., Li, J., Ding, T., . . . Zhou, J. (2017). Robust and Low-Cost Flame-Treated Wood for High-Performance Solar Steam Generation. ACS Applied Materials & Interfaces, 9(17), 15052-15057.

Yacef, R., Mellit, A., Belaid, S., & Şen, Z. (2014). New combined models for estimating daily global solar radiation from measured air temperature in semi-arid climates:

application in Ghardaïa, Algeria. Energy conversion and management, 79, 606-615.

Yadav, D. P., Bajracharya, S. B., & Bhattrai, S. (2017). Energy Saving Assessment for Building Envelope of Supermarket Based on EnergyPlus and Openstudio. American Journal of Civil Engineering, 5(3), 141.

Yang, H., & Lu, L. (2007). The optimum tilt angles and orientations of PV claddings for building-integrated photovoltaic (BIPV) applications. Journal of Solar Energy Engineering, 129(2), 253-255.

Yang, J.-h., Mao, J.-j., & Chen, Z.-h. (2002). Calculation of solar radiation on variously oriented tilted surface and optimum tilt angle. JOURNAL-SHANGHAI JIAOTONG UNIVERSITY-CHINESE EDITION-, 36(7), 1032-1036.

Yang, R. J., & Zou, P. X. (2016). Building integrated photovoltaics (BIPV): Costs, benefits, risks, barriers and improvement strategy. International Journal of Construction Management, 16(1), 39-53.

Yassine, M., & Lotfi, D. (2011). Technical Document and regulation; Thermal Regulations of Building. Algeria: National Center for Studies and Integrated Research of the Building Retrieved from https://www.scribd.com/doc/171884035/Reglement-algerien-sur-les-thermiques-des-batiments-version-de-05-09-2011.

Yoon, J.-H., Song, J., & Lee, S.-J. (2011). Practical application of building integrated photovoltaic (BIPV) system using transparent amorphous silicon thin-film PV module. Solar Energy, 85(5), 723-733.

Yoshikawa, K., Kawasaki, H., Yoshida, W., Irie, T., Konishi, K., Nakano, K., . . . Uzu, H. (2017). Silicon heterojunction solar cell with interdigitated back contacts for a photoconversion efficiency over 26%. Nature Energy, 2, 17032.

Zahedi, A. (2006). Solar photovoltaic (PV) energy; latest developments in the building integrated and hybrid PV systems. Renewable Energy, 31(5), 711-718.

Zemmouri, N. (2010). Achieving Environmental Security: Ecosystem Services and Human Welfare (W. G. K. P. H. Liotta Ed.). Department of architecture, University of Biskra, Algeria.

Zemmouri, N., & Schiler, M. E. (2005). Modelling Energy Efficient Windows in hot arid zones. Paper presented at the The 22nd Conference On Passive and Low Energy Architecture-PLEA.

Zhang, W., Lu, L., Peng, J., & Song, A. (2016). Comparison of the overall energy performance of semi-transparent photovoltaic windows and common energy-efficient windows in Hong Kong. Energy and Buildings, 128, 511-518.

Zhang, X., & Du, J. (2015). Lighing Performance In Office Buildings with BIPV Facades: Visual and Non-visual Effects.

Zhou, C., Liang, R., Zhang, J., & Riaz, A. (2017). Experimental Study on Dynamic Thermal Response of Building Attached Photovoltaic (BAPV) Curtain Wall System. Procedia Engineering, 205, 314-320.

Zhu, D., Hong, T., Yan, D., & Wang, C. (2013). A detailed loads comparison of three building energy modeling programs: EnergyPlus, DeST and DOE-2.1 E. Paper presented at the Building Simulation.

Zinßer, B., Makrides, G., Schubert, M., Georghiou, G., & Werner, J. H. (2008). Temperature and intensity dependence of twelve photovoltaic technologies. Paper presented at the Proceedings of the 23rd European photovoltaic solar energy conference.