J. Build. Mater. Struct. (2024) 11: 1-19 ***Original Article***
DOI: 10.34118/jbms.v11i1.3228

Analyzing Energy Efficiency Strategies and Designing and Simulation Energy Efficient Systems in Buildings

Peyman afroozeh

Department of Elite Relations with Industries, Fars Construction Engineering Organization, Shiraz P.O. Box 9185816744, Iran
* Corresponding Author: peyman.afrouzeh@yahoo.com

Received: 01-07-2023 **Accepted: 13-01-2024**

Abstract. Green building (also known as green construction or sustainable building) refers to both a structure and the application of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from planning to design, construction, operation, maintenance, renovation, and demolition. The past decade has witnessed a rapid increase in the number of studies on GB energy efficiency systems. However, similar studies also indicate that the results of current GB simulations are not yet satisfactory to meet GB objectives. In this study, every particular part of the building construction element was simulated for ensuring energy efficiency. Additionally, a method is introduced that almost satisfies GB objectives by using appropriate modern cost-effective technologies. This method reduces the initial, running, and maintenance costs of electrical/electronic devices and limits wiring installations, leading to significant energy consumption reduction of about 50%. In this research, renewable energy or green power, that is currently the key solution to tackle the energy crisis, significantly maximised, hence decreasing the impact of global greenhouse gas emissions.

Keywords: Green Buildings, Renewable Energy, Solar Energy Analysis.

1. Introduction

Green Buildings (UK) are also known as Energy Efficient Buildings. After the oil crisis that began in 1973-1974, government agencies and private companies began looking for alternative ways to intelligently use existing energy resources and minimize unnecessary consumption. This opportunity has led to the development of a wide range of energy research practices and simulations to reduce energy consumption in buildings. A recent UK study found that traditional/conventional buildings waste enormous amounts of energy and produce the highest carbon dioxide (CO_2) emissions in the construction industry. In addition, these studies also identified the top three contributors to greenhouse gas-emissions: manufacturing, transportation and buildings. In this regard, traditional/conventional buildings account for up to 43% of total global greenhouse gas emissions. The solution to address this significant negative impact on the construction sector is to implement the GC globally as soon as possible and define the GC and its purpose.

1.1 Energy Simulation of Building Elements

The focus of this research project is to investigate the extent of energy savings that can be achieved using comprehensive energy savings methods in commercial office buildings. For this purpose, all building elements and materials used in building construction were simulated to identify energy wastage. For example, the orientation of windows and doors and the type of building materials used have a significant impact on energy consumption. In addition, solid concrete walls are mostly used in commercial buildings as they can provide an important building envelope. In addition, such walls also play an important role in heating/cooling zones due to their natural thermos-mass properties that allow building materials to absorb, store and later release heat (Mehta, 2013; Milovanovic et al, 2012; Tih-Ju et al., 2014; Zhu 4 et al, 2009). These materials have the natural behavior of slowly absorbing energy and storing it over long periods of time. This delayed response reduces heat transfer by thermal mass and shifts energy demand to off-peak hours. Thus, reversing the heat flow within the walls saves energy. Significant energy savings are also made during this time, as mass and heat flow play a major role in compensating for temperature fluctuations. In addition, the window-to-wall ratio (WWR) also plays an important role in ensuring energy savings. In winter he high WWR can allow additional light into the building, which can lead to significant heat loss in summer (Kwon et al, 2018). In addition, windows and doors form a large part of the building envelope and have a significant impact on human activity and energy consumption within the building.

Sustainable window design maximizes daylight benefits while minimizing energy consumption. Sustainable GB design and its objective goals are expected to provide 80% (Sherif et al., 2012) of interior lighting from natural light and to ensure sufficient natural ventilation by minimizing/maximizing window sizes. I'm here.

1.2. Sustainable Green Building Modeling and Design

The design and modeling of a sustainable green building (GB) that meets the overall requirements or scope and objectives of a BS is highly complex requiring the efforts and commercial success of many collectives. It's a process. However, the opportunity to design and model the GB using inexpensive, modern, reliable and industry-proven technology such as the "Actuator Sensor-(AS) Interface Network Protocol", which is used in many industries today, there is share used ones, save space and installation costs. The use of this kind of technology in the building sector will improve the energy consumption impact of buildings, achieving the scope and objectives of GB through cost savings. (Kuo et al., 2016) The main purpose of this research is to model and design smart buildings using state-of-the-art technology (Wong and Li, 2006). This makes the GB a truly Energy Efficient Building (EEB) (Gadakari et al, 2014).

1.3. Building Energy Simulation

GB energy analysis simulation software uses BIM as a source of engineering data information to achieve high performance of GB preliminary design goals (Wang et al, 2004). Since the 1990s, many software companies have developed their own software simulation packages. However, each package has advantages and disadvantages. Some packages have great features but poor interfaces, while others have great interfaces but limited functionality (Mláček, 2016). Effective use depends on the purpose for which the software is used and whether the user has the skills and knowledge to implement the software.

- Smart Buildings

Today, buildings with advanced technology using the Internet of Things (IOT) and ancillary services provided by powering the grid are highly populated to smart city development. It focuses on approaches (Lilis et al., 2016).

1. Based on annual HVAC consumption.
2. Optimized use of renewable energy, especially PV cells.
3. Building water consumption: GB water for cooling and cooling. The greatest savings occurred when connected to efficient systems that met the needs of Heating reduces and minimizes the energy required to perform these tasks, reducing costs. Some studies show

that up to 15% of energy consumption in commercial buildings can be attributed to hot water heating (Chan, 2007).

4. Control methods for building equipment, electrical and electronic equipment, and plug-type equipment. This type of energy saving is achieved by controlling and monitoring the activity of these devices so that they work only when needed.

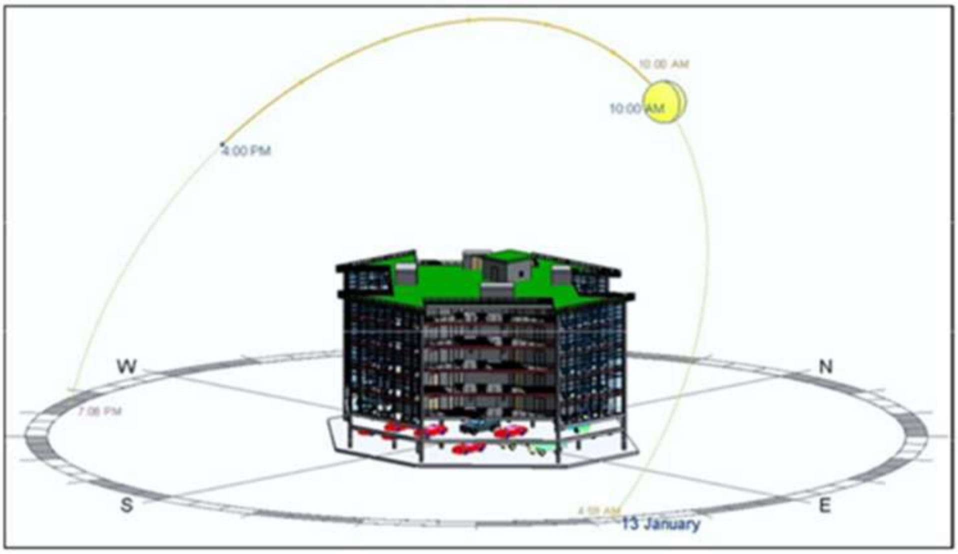


Figure 1. Base run building solar energy simulation.

1.4. Base Run Building Solar Energy Simulation

This document treats his two main topics, "Base Run Solar Building Energy Simulation" and "Renewable Energy Sources Simulations" as sub-chapter sections.

The Building Solar Energy Simulation focuses on the concept of how much solar radiant energy a building element can absorb on a clear, sunny day. This type of simulation procedure can be performed using different techniques and step procedures. It depends on the researcher's skill and choice of appropriate tools. One technique is building orientation.

Direction is defined as the position of the building taking into account seasonal variations in the path of the sun, as the intensity of solar radiation varies accordingly. Optimal building orientation can make a building more energy efficient, more comfortable for residents and workers, and more cost-effective to operate a building.

2. Simulating Renewable Energy

Renewable energy is clean and inexhaustible. Renewable energy differs from fossil fuels primarily in its diversity. Renewable energy is plentiful, emits no greenhouse gases or pollutants, and can be used anywhere in the world. Moreover, the cost of renewable energy has been declining over the long term, and the general cost trend of fossil fuels is going in the opposite direction despite current volatility.

2.1. Building Solar Energy Simulation Process

Building Solar Energy Simulation can be done either at Conceptual Mass or Whole Building Elements. "Conceptual Mass" simulates the building as a mass block.

2.2. Building Energy Daily Solar Simulation

For the purposes of this thesis project proposal, a building solar simulation was performed using Autodesk Revit Energy. Analysis of the buildings in a single day for six hours from 10:00 am to 4:00 pm on the summer solstice, as shown in Figure 1. Over the course of 6 hours, the solar intensity of the building solar simulation continues to increase until it approaches maximum intensity at noon.

Therefore, the building absorbs the maximum amount of solar energy at this time. After noon, the Sun's intensity steadily decreases, and so does its maximum intensity, reaching zero after 6:00 PM.

A simulation period of 6 hours was a reasonable time to help calculate the estimated annual average energy consumption of the building. During this solar building simulation process, each building element has a solar radiation intensity. Therefore, the solar energy building simulation

2.3. Basic run simulation parameter data

The input parameters (whose values are shown in Table 1) had a significant impact on the energy simulation process, resulting in significant energy savings. rice field. Similar to the input parameters, output parameters are proposed by the simulation system with significant cost-effective economic values.

Table 1. Base run building performance

Location	Iran, Shiraz
Weather station	600300
Outdoor temperature	Max 37°C, min 6 c
Floor Aera	1.306 m^2
Exterior wall aera	633 m^2
Average lighting power	10.23 w/ m^2
People	52
Exterior window ratio	1.48
Electrical cost	$0.06 kWh
Fuel cost	$0.78 them

2.4. Annual energy use intensity

Table 2 shows annual average electricity, EUI per kilo-watt hour, per square meter, per year (kWh/m2/year) in the first row, annual average fuel, EUI per Mega joule, per square meter, per year (MJ/m2/year) in the second row and total of both annual average EUI in the third row. EUI is a measurement of per-area metric, and it is a convenient method of comparing energy consumption when the analysed building model uses different energy sources. 710MJ/m2/year signifies good energy performance.

Table 2. Annual energy use intensity

Electricity EUI	125 kWh/sm/yr
Fuel EUI	262 MJ/sm/yr
Total EUI	710 MJ/sm/yr

2.5. Life-cycle energy use

The average energy simulation results for the building life-cycle period are shown in Table 3, with average annual life-cycle electricity use in the first row, average annual life-cycle fuel use in the second row, average annual life-cycle total cost in the third row and average annual life-cycle discount rate in the fourth row. Thus, the Autodesk Revit energy analysis simulation system algorism is intelligent enough to include the estimated discount rate (6.1% of an average annual cycle life of 30 years). These results represent the highest energy efficiency.

Table 3. Energy life-cycle use

Life cycle electricity use	5.073.816 kWh
Life cycle fuel use	10.676.574 MJ
Life cycle energy cost	$176.519
*30-year life and 6.1% discount rate for costs	

PV-modules and wind turbines are planted. Table 4 shows the efficiencies of three different types of PV cells. This reflects the ability of PV cells to convert sunlight into electricity, as well as wind power that can be generated from a 15-inch diameter horizontal axis. These system-provided renewable energy potential simulation results are obtained from three primary solar cell options ranging from 5 to 15% in the range of low, medium, and high efficiency, as described above. The average power yield at the highest level of efficiency is approximately 72,442 kWh per year. This is a high potential energy compared to the annual energy consumption of the building. Conversely, the proposed results of the wind turbine potential energy simulation are small compared to the annual energy consumption of the building. Potential wind energy in this area is not enough to generate sufficient energy. Conversely, the renewable potential of PV cells indicates that they are worth exploiting, even if they add acquisition and maintenance costs.

Table 4. Annual estimated potential energy

Roof Mounted PV system (low efficiency)	24.147 kWh/yr
Roof Mounted PV system (Medium efficiency)	48.295 kWh/yr
Roof Mounted PV system (High efficiency)	72.442 kWh/yr
*PV efficiencies are assumed to be 5%, 10% and 15% for low, medium and high efficiency systems	

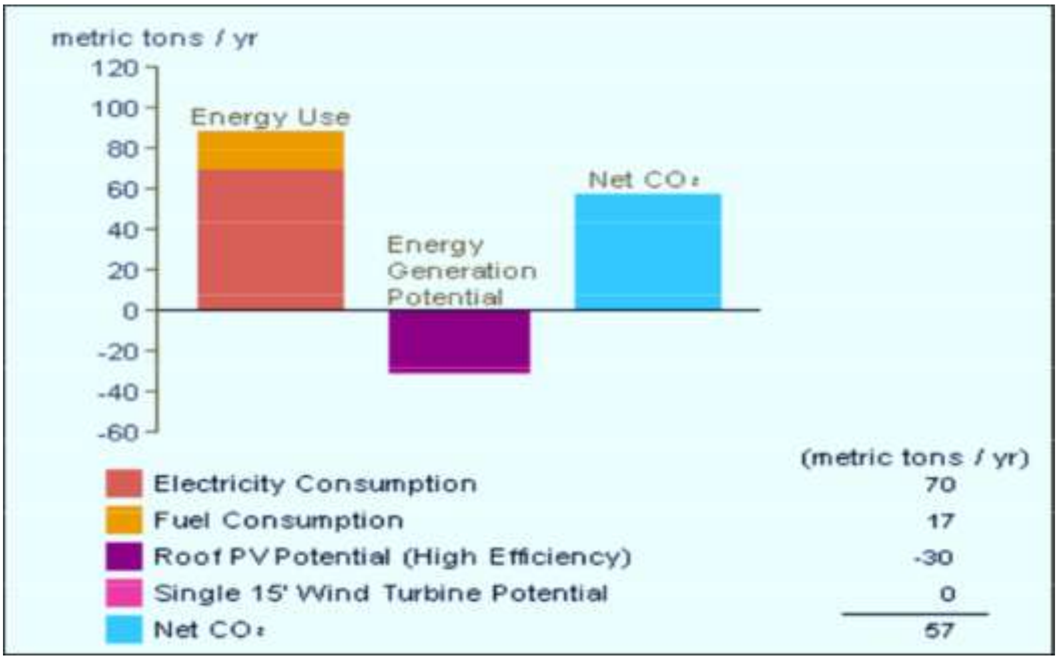


Figure 2. Annual carbon emission and net CO_2 Calculation

Carbon (70 + 17 = 87) and negative carbon emissions 87 − (30 + 0) = 57 are produced mainly by renewable energy sources from PV cells. The net CO_2 was found to be equivalent to 57 tonnes per year. This is a significant reduction in energy consumption compared to achieving carbon neutrality. This means that as energy consumption, especially fuel consumption, increases, so does CO_2 emissions proportionally. Furthermore, PV cells not only provide high potential energy in kilowatt-hours, but also act on the CO_2 negative process (removal of carbon-CO_2 from the connecting area). In this process, wind turbines are only used to ensure CO_2 neutrality.

To calculate carbon emissions for the Shiraz project in Iran, Autodesk Revit used utility emissions data from Carbon Monitoring for Action data. Project emissions data is based on on-site fuel consumption and fuel sources generated by local electricity consumption.

For example, a project in an area with coal-fired power plants will emit more CO_2 per kWh of electricity consumed than a similar project in an area with hydroelectric power plants (Lin and Ahmad, 2016; Günel, 2016; Berman, 2012).

2.6. Annual Energy Consumption Cost

The base run simulation report in Figure 3 shows the total annual energy consumption cost for electricity and fuel. Fuel consumption and power consumption are different. However, the electricity cost per kWh is higher than the fuel cost for the same kWh. This is a great way to use alternative low-cost energy. The Autodesk Revit base run energy simulation list shows a power cost of $0.06 per kWh and a fuel energy cost of $0.007 per MJ. MJ is converted to kWh using the universal energy conversion formula 1 kWh = 3.6 MJ. Do the math: $0.007 x 3.6 = $0.0252. Therefore, the cost of using fuel energy is very economical compared to the cost of using electrical energy. Annual energy cost and consumption information allows you to compare building energy costs and early planning decisions. Costs are estimated using national, statewide, or statewide average utility rates.

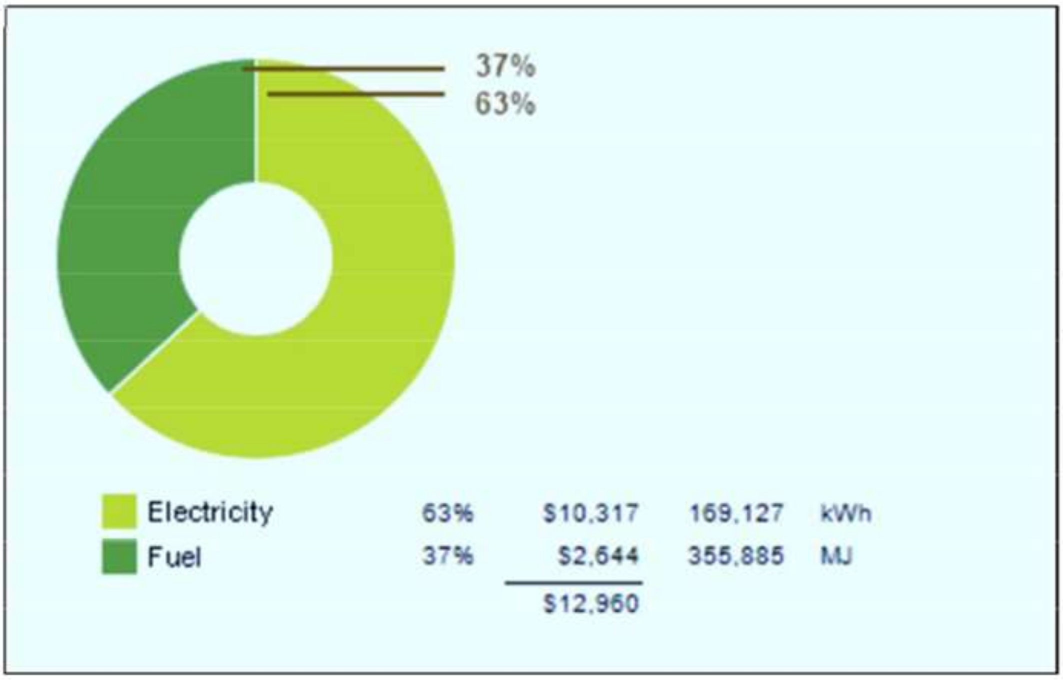


Figure 3. Annual Energy Usage Costs.

2.7. Annual Fuel Energy Consumption

Building energy is primarily consumed by HVAC systems, both of which consume significant amounts of energy (electricity and fuel). The HVAC and hot water load analysis report graphs shown in Figure 4 show the energy consumption of each. Analysis of this graph report shows that HVAC load dominates energy consumption (92%), while hot water consumption is significantly limited at least 8%. This means that the simulation system used to analyze this energy simulation is a very effective way of using/programming hot water by avoiding periods of peak demand. demand time. This is one reason why HVAC loads consume so much power. However, in two opposite seasons (hot/cold) it is not easy for him to significantly minimize the use of HVAC loads. Especially during peak demand. This graph shows the percentage of total fuel used, the cost, and each unit of each end-use to help determine the estimated end-use. You can plan.

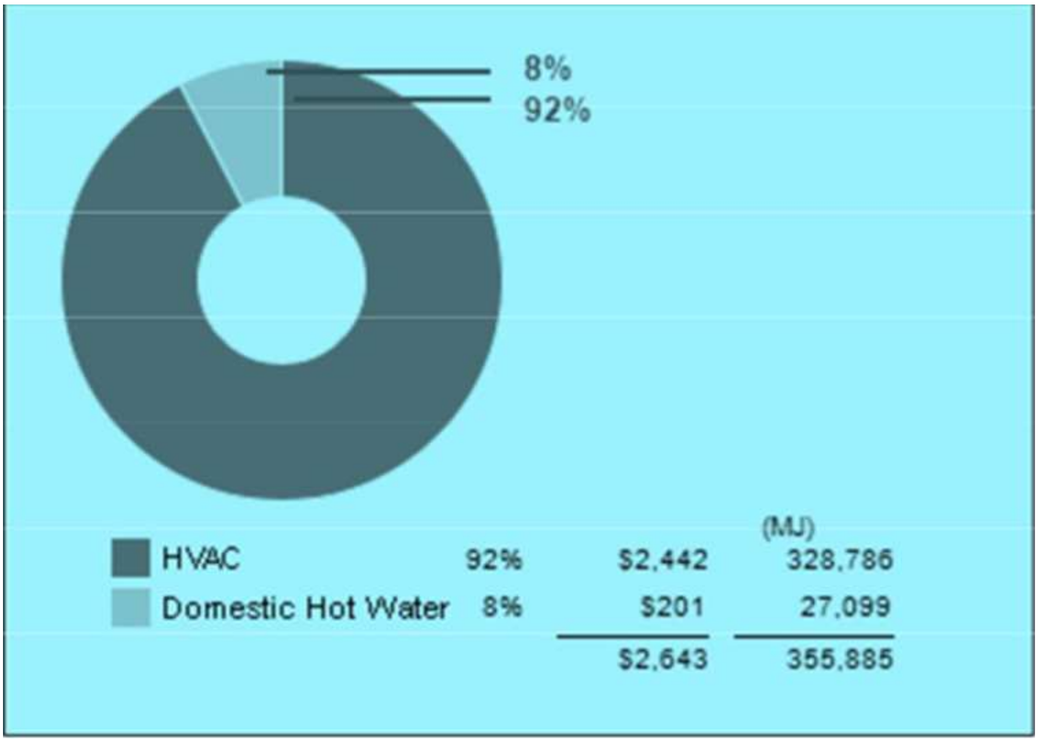


Figure 4. Annual fuel energy use.

2.8. Annual Power Consumption

The Base Run Energy Simulation summarizes the consumption of each energy source and shows users where to save energy and avoid unnecessary energy consumption. Figure 5 shows how the final consumption energy load is provided among the main energy consumers of the building.

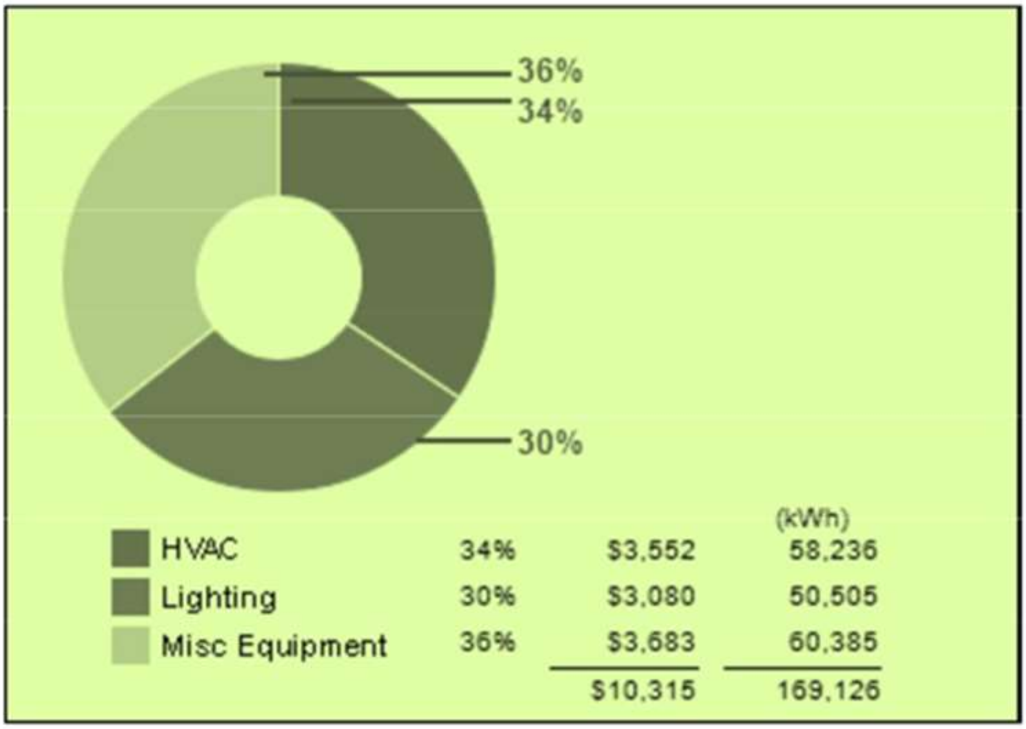


Figure 5. HVAC, lighting and other equipment annual energy usage

We find that utility energy and costs are evenly balanced between HVAC, lighting, and other equipment loads in this configuration. Other equipment includes computers, elevators, and other equipment. For each end-use, the graph shows percentage of total power usage, cost and kWh

By understanding the end use that requires the most electricity, this can be focused on in the strategic plan to reduce overall energy consumption for the project. For example, the strategic plan will be very helpful in determining ways to program/schedule equipment function time, to ensure cost-effective use to according to the utility energy Supply Company's rate for the peak-demand and nonpeak-demand periods.

Peak-demand period rates information data can be found from the utility energy supply energy company website or by directly calling the company call center.

2.9. Annual, monthly heating load

The base run energy simulation calculates the building's annual energy in annually summarised reports, but in addition, it also calculates monthly details of cooling, heating, fuel, electric and peak-demand loads, as shown in Figure 6, where each particular building element/part is simulated against its capabilities of being energy efficient and ability to absorb solar energies, such as concrete walls, curtain walls, roofs and conductive windows, which are substantial examples. At present, the concept of green roof is emerging for its ability to reduce heat flow into and out of the surface covered. There is also evidence that the benefits are much greater in summer, as plant leaf reflectance and evaporation rates are maximized in summer. A green roof reduces heat flow through the roof and reduces the energy used for cooling or heating, which can result in significant cost savings. Shading the exterior of a building has proven to be more effective than interior insulation. In summer, the green roof protects the building from the direct heat of the sun. June's biggest drawback is the window line. Heat loss through window conduction represents the largest monthly heat demand in June. However, various devices such as electrical outlets, computers, and office equipment reduce the need for heat. Use this chart to identify critical components for reducing the heating load on your project. In this example, windows cause the greatest heat loss. The roof and walls significantly reduce heat loss. Therefore, to reduce the heating load, we should focus on the window and reduce its U value.

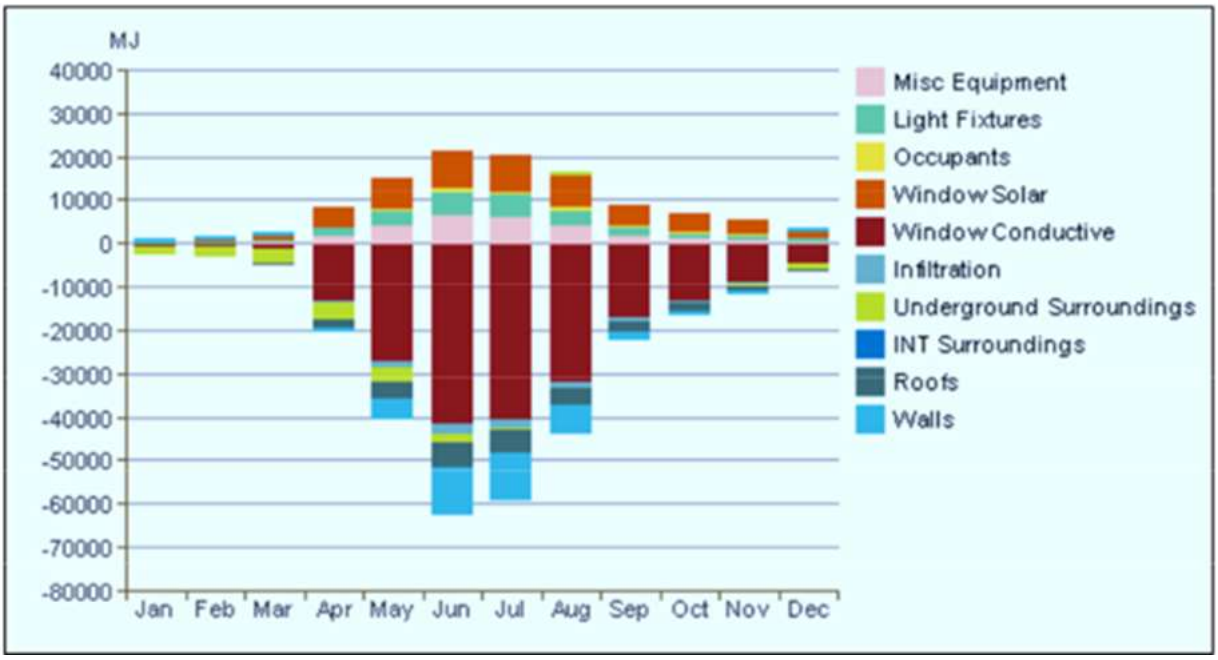


Figure 6. Annual energy consumption, monthly heating load.

2.10. Annual monthly cooling load

As shown in Figure 7, the monthly cooling load is contributed by each building element material. Walls contribute the most to cooling, followed by the roof and conductive windows. Solid concrete walls are primarily used in commercial buildings due to their ability to provide critical building envelope functions. In addition to its primary function as a building envelope, the natural thermal mass properties that allow the building material to absorb, store and later release large amounts of heat make it important in climatic conditions for heating/cooling zones. play a role. Concrete and masonry buildings have their own significant energy saving advantages due to their inherent thermal mass. These materials have the natural behavior of absorbing energy slowly and retaining it much longer than materials with less mass. Mass and heat flux inversions play an important role in gaining dominance in climates with large diurnal temperature variations above and below the equilibrium point. In these conditions, the concrete mass building skin is easily cooled by natural ventilation at night and absorbs heat or floats during warm days. When the outside temperature is at its hottest, the inside of the building stays cool because the heat has not yet penetrated the mass. A positive value represents a cooling demand that must be met by the cooling system or other means, and a negative value compensates for the cooling demand. For example, heat transfer through closed windows can cool a building at night if the ambient temperature is low enough. The greatest cumulative cooling load he occurs in June, with the greatest increase in solar energy through windows or solar radiant heat through windows. However, the heat gain from the walls is relatively small. So, before you invest in improving the insulation value of your walls, you should improve your glass to reduce the solar heat gain rate of your windows. Starts increasing with a semi-linear slope over the three months of March

This semi-linear slope peaks in mid-June and declines non-linearly again for three months. The project uses fuel energy sources for heating as opposed to electric heating sources, and fuel energy consumption increases during the colder months of the year.

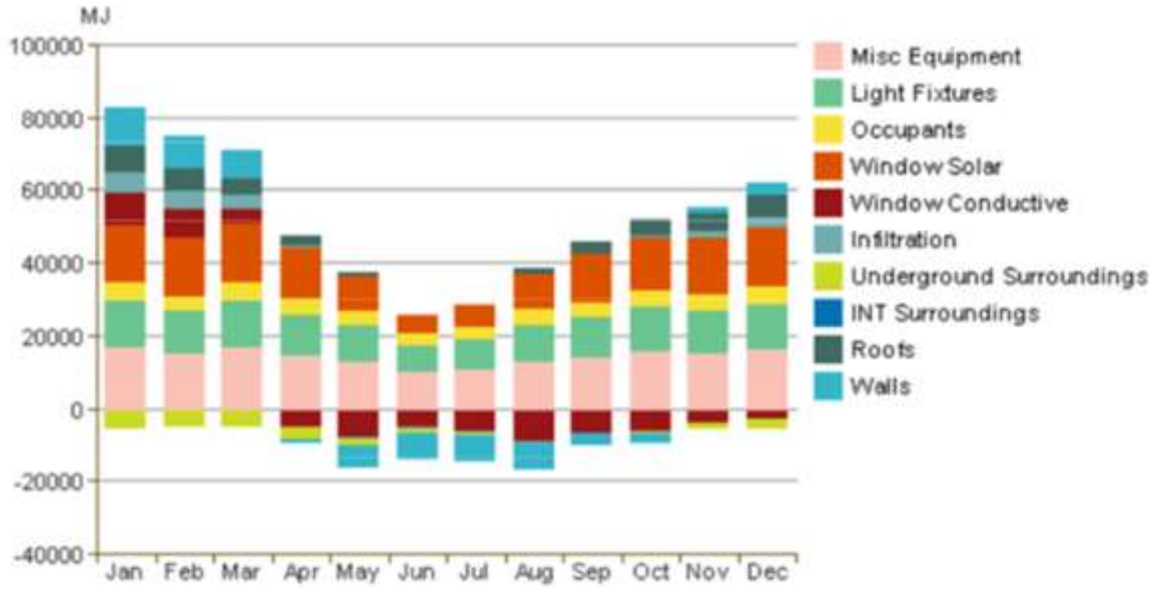


Figure 7. Annual energy usage, monthly cooling load.

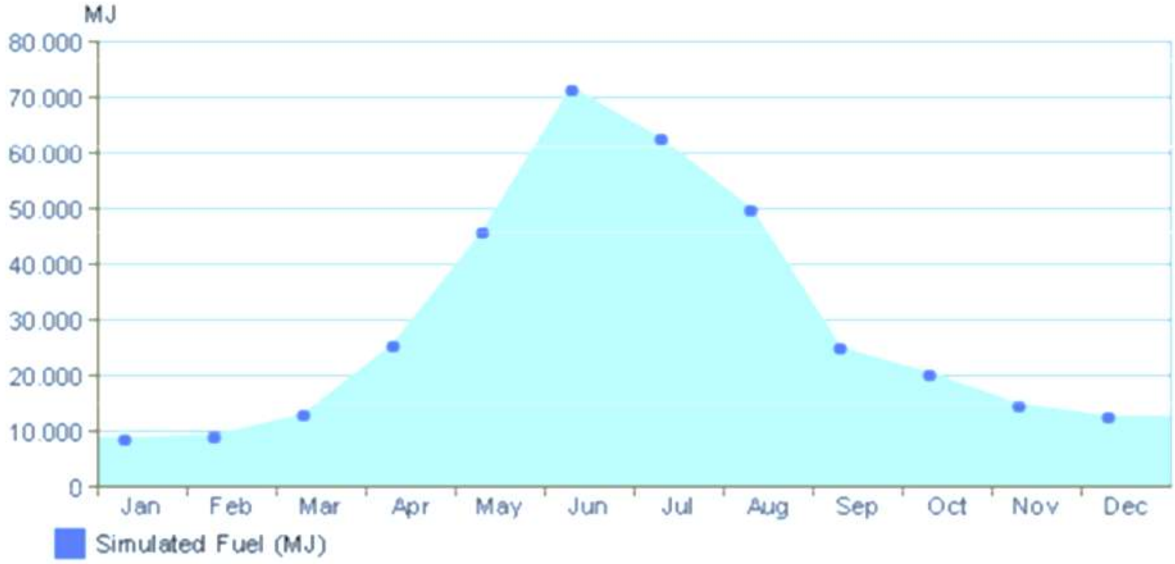


Figure 8. Annual Fuel Consumption.

2.11. Annual Electricity Consumption Load

An electrical load is an electrical component or part of an electrical circuit that consumes (real) electrical energy. This is in contrast to power sources such as batteries and generators that produce electricity. Examples of loads in the circuit are electrical appliances and lamps. The power dissipating load shown in Figure 9 affects circuit performance in terms of output voltage or current as follows: B. Sensors, Voltage Sources, Amplifiers.

Figure 9. Annual, monthly electricity consumption.

Power receptacles provide full rated supply power at constant voltage by grouping hard-wired electrical components/devices connected in a circuit to form a load. Therefore, the load impedance drops significantly when high power devices are connected or turned on. If the load impedance is not much higher than the source impedance, a voltage drop will occur quickly. In commercial/residential buildings, turning on the heater can significantly dim incandescent lights. On using air-conditioning as the main cooling supply to the building rather than using duct gas cooling supply, electricity usage increases during the hotter months of the year, as shown in Figure

9 which is during the months of January and March, when the electrically supplied usage loads approach the maximum point.

2.12. Base Run Simulation, Weather Files Contribution

Building solar energy simulations use weather files as measurement factors/parameters to achieve accurate energy usages and cost. Hence, energy costs are highly affected by weather files, such as annual Wind Rose (wind speed). This wind speed distribution is used in building solar irradiation energy simulations as factors or parameters to enable the simulation process system, in which the estimated annual total energy, the total life-cycle energy and the annual renewable potential energy simulations are calculated based on the exact current distribution of the annual wind speed. Knowing the annual current wind speed is not only useful to obtain accurate estimated building energy simulation, but it also contributes significantly to building sustainable GB in terms of stability.

Additionally, hourly wind roses play a similar role to wind speeds. Hourly wind speed is measured in frequency (Hz). This means the amount of air that recurs or is present in the area in an hour.

2.13. Annual, monthly and hourly wind speed distribution

The baseline version of Autodesk Revit Energy Simulation Analysis formats hourly weather files to define external conditions during the simulation process.

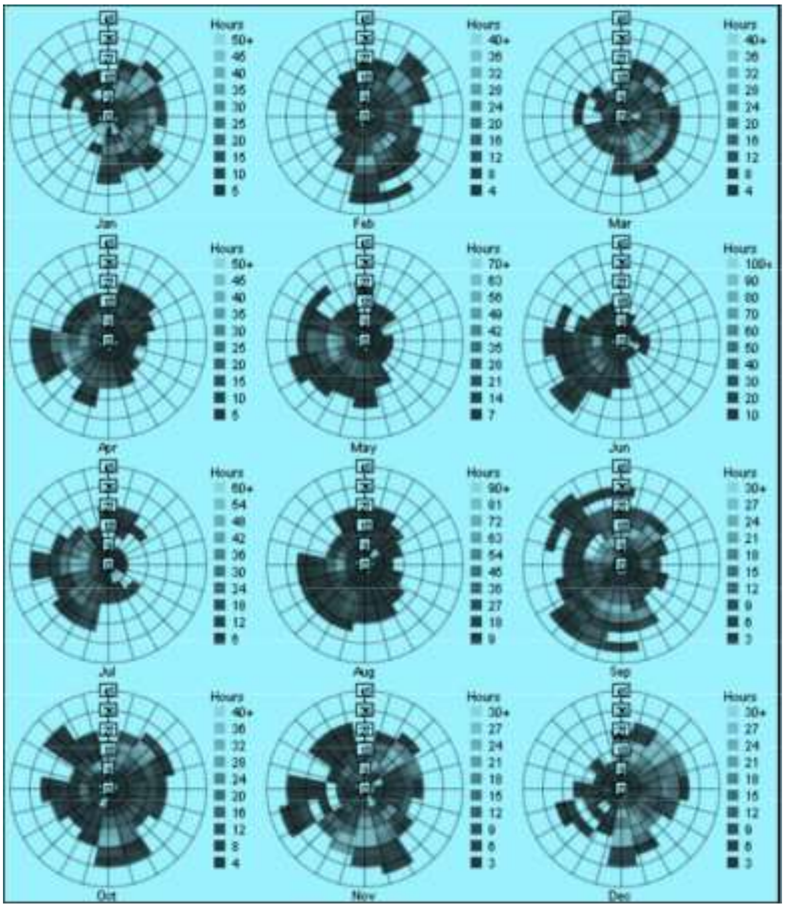


Figure 10. Annual, monthly and hourly regional wind frequency distribution.

2.14. Base Run Building Energy Simulation Analysis

To achieve maximum energy in GB, whole building energy modelling (BEM) is necessary and it is a versatile multipurpose tool that can be used in a new building and for example, for retrofit design, code compliance, green certification, qualification for tax credits, utility incentives and real-time building control (Alwaer and Clements-Croome, 2010). In addition, BEM is also used on a large scale in analyses to develop building energy efficiency classification codes. These codes are used to help responsible authorities and policy decision makers.

The Autodesk Revit energy analysis, base run building energy simulation is fed information data in the first step (simulation part one). Data are provided as parameter inputs with specific details and units so that simulation software applications can accurately and efficiently compute specific tasks in a minimal amount of time. Examples of informational data used are building area/spatial data, location, weather files from the nearest weather station, and energy cost per energy current, as detailed in Tables 1 and 2.

In the second step of the simulation process (Part 2 Simulation), the computer simulation uses the material and building information data of these randomly selected building elements as input parameters to generate baseline data as basic output. Generate an analytical energy simulation model. As such, the content is primarily focused on four summaries of building energy simulation results. The first column is Energy Cost Summary, Annual CO_2 Emissions, Annual Energy Consumption, and Building Life Cycle Energy Consumption.

These base-run energy simulation results are expected to improve in the advanced energy simulation process for alternative designs, as many alternative energy simulation packages are simulated sequentially. Therefore, this type of method facilitates the selection of the best building energy simulation package by comparing each simulation package with other packages and with the simulation results of the base run. In this way, we can find the optimal energy-saving package from 254 alternate runs.

2.15. Renewable Energy Simulation

Renewable Energy Simulation covers many new and alternative energy sources. However, the most valuable, especially in commercial buildings, are PV cells and wind turbines. Therefore, this paper uses the policy proposed in the baseline simulation for renewable energy deployment and excludes other renewable energy sources. Proposed renewable energy sources are 15% efficient PV cells and 15-inch wind turbines. Recognizing that these sources lie in initial efficiency and performance, and improving/optimizing efficiency and performance is one of the tasks in designing for GB energy sustainability. Therefore, this research section focuses on how to optimize currently commercially available renewable energies, especially PV cells and wind turbines.

- PV Cell Efficiency and Power I need to understand those calculations.

The following symbols are recognized worldwide.

Angle of inclination (δ), latitude (φ), azimuth or azimuth (AZ), zenith angle (Θz), sun position angle (α), and hour angle (W).

Before installing a PV cell, it is important to have a good knowledge of general solar irradiance from the sun to the earth and its basic phenomena as described above. The Sun is therefore a sphere composed of hydrogen and a hydrogen energy fusion generator known as the primary energy source, located about 1.5 × 1011 meters from the Earth. The sun produces or radiates an evenly equal average energy of 3.8 × 1026 watts in all directions from its surface.

The Earth only receives a fraction of this, about 1.7 x 1011 Watts. This is also enough to keep the earth warm and sustain life on it. Not all of the Earth's energy reaches the surface. Solar energy radiation faces many obstacles before reaching the Earth's atmosphere. The sun emits a composition of different energy levels called the solar spectrum. It consists of 40% or more infrared wavelengths, 50% visible light wavelengths, and 10% or less ultraviolet wavelengths. Some of this radiation hits the earth's surface at various angles of incidence and intensities. The total solar radiation reaching the Earth's surface is about 950 watts/m 2 and is distributed in three directions known as global horizontal irradiance (GHI), diffuse horizontal irradiance (DHI), and direct normal irradiance (DNI) approach. The medium in the atmosphere greatly distorts solar radiation, splitting it into parts, some of which are reflected directly from the medium, some of which is refracted horizontally, and most of which reaches the surface through the medium. Incident rays that reach the ground consist primarily of two rays, DHI and DNI equal to GHI. It is important to know how solar radiation approaches the earth's surface. Irradiance never approaches the surface at full intensity except at 12:00 PM. This is because the earth's position and orientation relative to the sun is not constant, so most of the time the radiation or light from the sun reaches the surface at an angle, reducing the intensity and efficiency of the radiation. solar cell. To compensate for these declines, many researchers have developed solar irradiance tracking systems using advanced techniques. For example, intelligent sensors, servo motors, algorithms to control movements, MPPT trackers and his GPS control system for mechanisms.

- Extraterrestrial radiation

Extraterrestrial radiation (Watts per square meter) is the solar radiation tangentially incident on the surface of the Earth's atmosphere as a function of time, i.e., is represented.

$$I_0 = \frac{12.3600}{\pi}\, G_{SC}\left(1 + 0.033.cos\frac{360.n}{365}\right)\left[\cos\varphi.\sin\delta\ \ (\sin\omega_2 - \sin\omega_1) + \left\{\frac{\pi(\omega_2 - \omega_2)}{180}\right\}\sin\varphi.\sin\delta\right]$$

$$H_0 = \frac{24.3600}{\pi}\, G_{SC}\left(1 + 0.033.cos\frac{360.n}{365}\right)(\cos\varphi.\sin\delta\ .\sin\omega s\ \ + \left\{\frac{\pi.\omega s}{180}\right\}\sin\varphi.\sin\delta)$$

Where Solar Constant, G_{sc} = watt/m^2

Hourly Radiation = J/m^2

Daily Radiation = J/day.m^2

The ideal characteristics of the PV cell are = 0.623, ideal = 35 mA/cm^2, FFIdeal = 0.83, real cell: = 612, Isc = 34.6 mA/cm^2, FFreal = 0.67.

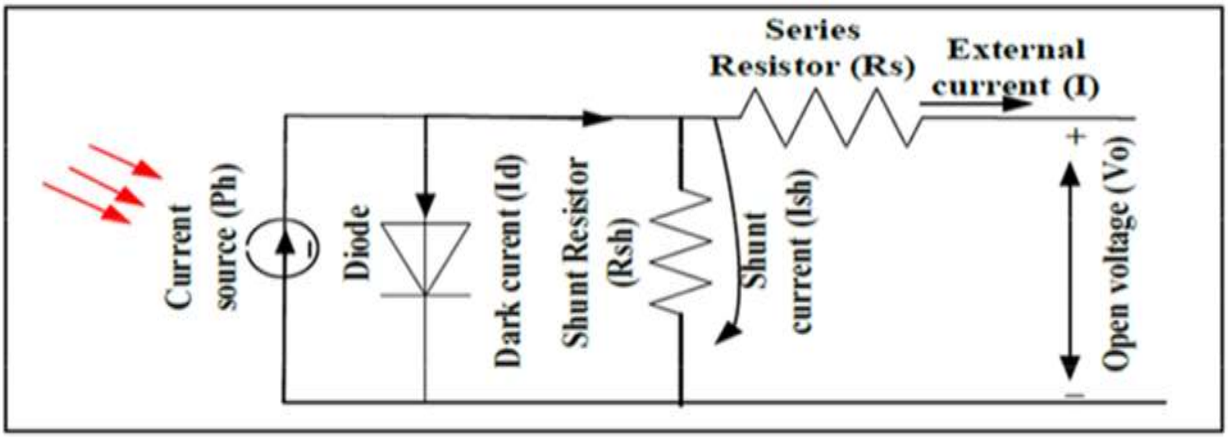
2.16. PV Cell Current Generation

Light contains particles called photons, and when these photons hit the surface of a semiconductor, they can be reflected off the surface, absorbed into the material, or Both are likely to be absorbed by the transfer material. Reflection and transmission are usually considered losses in PV cell devices because unabsorbed photons do not generate energy. When a photon is absorbed, it has an opportunity to excite an electron from the valence band to the conduction band. A key factor in determining photon energy is whether it is absorbed or transmitted.

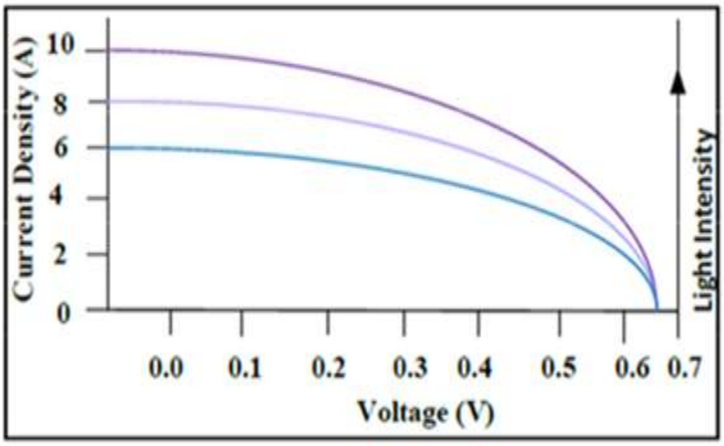
An electron is excited from the valence band to the conduction band only if the photon has sufficient energy. If the photon's energy is greater than or equal to the material's bandgap, the photon is absorbed by the material, exciting an electron into the conduction band. In addition, materials with higher absorption coefficients (=4) absorb photons more readily and excite electrons into the conduction band. Absorption coefficient determines the distance that light of a particular wavelength can travel through a material before being absorbed

The absorption coefficient depends on the material and the wavelength of light absorbed. For satisfactory PV cell performance, the solar intensity, which consists of many different wavelengths and energies, must be able to absorb enough short-wave photons, and PV cell materials have higher absorption coefficients. must be Therefore, if the photon energy is (=), E is the energy in joules, h is Planck's constant (6.626 × 10-34 joules), c is the speed of light (2.998 × 108 m/s), and λ is At wavelength, the above equation leads to the inverse correlation (= = 6.626× 10− 34.2.998× 108 = 1.99× 25−10−). The inverse relationship means that light composed of high-energy photons (such as blue light) has a short wavelength, and light composed of low-energy photons (such as red light) has a long wavelength. When working with particles such as photons and electrons, the common unit of energy is the electronvolt (eV) rather than the joule (J), which is the energy required to raise an electron by one volt. For a photon with an energy of 1 eV=1.602×19−10J, its wavelength is calculated as (= = 6.626×10−34.2.998×108 = 1.99×25−10 Joule−m 1.602×19−10J= 1.24 6−10); therefore, this microwave length is sufficient to knock off electrons from the PV cell.

Figures 11 (a), (b) and (c) show the ideal and non-ideal diode characteristics of a PV cell with respect to light intensity penetration and maximum output voltage generation, called IV characteristics. This section briefly describes diode characteristics in terms of dark current, shunt current, and series current. Relationships between current density, luminance, open-circuit voltage, and their corresponding values. The values of shunt short circuit current and open circuit voltage are simulated to improve the efficiency of PV cells.



a) PV cell diode characteristics, dark current, shunt resistance and series resistor



b) PV cell diode current density

Figure 11. PV cell characteristics.

The main purpose of this white paper is to simulate a PV cell system. Incident light tracking has been previously demonstrated by several researchers using mechatronic systems of control practice. This research project developed an alternative method that works with a similar concept but uses a simpler method and is less expensive.

The method developed in this research project is that the PV cells generate an electric current depending on the intensity of the sunlight. A PV cell produces a current proportional to its sensitivity to sunlight. Therefore, PV cells receive maximum sunlight intensity around noon, and during this time PV cells generate maximum power. However, the power generation capacity of solar cells is affected by many factors. For example, the position of the sun in the morning and evening sky with respect to azimuth, the seasonal inclination (declination) of the earth, and how far the position of the sun on the horizon is from the zenith angle. Anything that affects the intensity of sunlight. Considering all these factors, this alternative method system was developed to compensate for the power loss caused by these influencing factors to achieve maximum output power from almost morning till night. The alternative is that if the PV cell's semiconductor is covered with an adaptive component or curtain wall material, this adaptive component has the ability to sense the intensity of sunlight and reorient itself to match the alignment position of the sun. It is also based on a very simple concept.

This is done by tilting the PV cell modules into flexible tilt angle positions and programming them to follow where the sun is facing up in the sky, ensuring that the PV cells receive nearly constant incident light perpendicular to their plane. I mean However, because the sun is far away from the PV cells, the light intensity varies during the morning and evening hours, but the incident light is always concentrated at the normal and normal position angles of the PV cells.

This concept was tested using a software simulation application, as shown in Figures 12-14. Therefore, as shown in Figure 11, the vectors in the simulation process algorithm point to the sun and PV cells, aligned/misaligned with each other. Three main positions are then identified as positions 1, 2, and 3, depending on the position of the sun. Position 1 is the morning hour (7:12 AM), position 2 is past noon (1:46 PM), and position 3 is the beginning of the evening hours (2:12 PM).

1) Position 1

As shown in Figure 13, Position 1 is not effective because the sun is still rising above the horizon and the vector angle is open.

2) Position 2

As shown in Figure 14

3) Position 3

At Position 3, the Sun is approaching the other side of the Earth. Actual time is evening. The impact of the sun on the PV cell panel is very similar to that of position 1, except that the azimuth has a negative sign and the PV cell panel is partially closed.

PV cell efficiency increases as the output power increases. The increase in output power is due to the increase in current. As mentioned earlier, the current in a PV cell changes proportionally to changes in solar irradiance. All the required parameters are displayed, except the PV cell panel area, initial active current, actual potential difference, PV cell panel initial efficiency and thickness, the rest parameters depend on the solar panel. Irradiation light intensity. As the sun moves from one position to another, the software script program shown in Figure 15 controls the Autodesk Revit parameters and adjusts their values according to the position of the sun in the sky. Ideally, as the light intensity increases, the PV cells reach their maximum output at 8 amps or more, say 10 amps, and there are 36 PV cell panels (10 × 36 = 360 amps). In the morning the angle of incidence is zero and the current is zero, but as the sun continues to rise above the horizon the angle of incidence approaches 90°. Current and efficiency are also close to maximum.

Without a solar tracking system, the best efficiencies of PV cells on the market today are in the range of %5 to %27, and adding all the associated and maintenance costs, this efficiency is not very satisfactory. It's either difficult or not possible. Several studies have now shown that many different methods have been proposed to improve the low efficiency of PV cells. One of them is the solar intensity tracking system, which has been shown to increase the efficiency of PV cell solar tracking systems from low base efficiency to over 40%, especially in cold climates. This is an important and elegant approach, adding small and expensive high-tech devices to more than double the base efficiency. However, this type of process is still not economical. The main goal of this research article is to develop a method that works in concept similar to solar tracking systems, but should be much cheaper and produce the same or nearly the same amount of energy. With this method, the solar cell approaches maximum current at an angle of 80.754° at 1:45 PM.

Theoretically, the maximum power should approach at 12pm and at the angle of °90, but the mismatch could result from the performance of the software in relation to the Sun's orientation

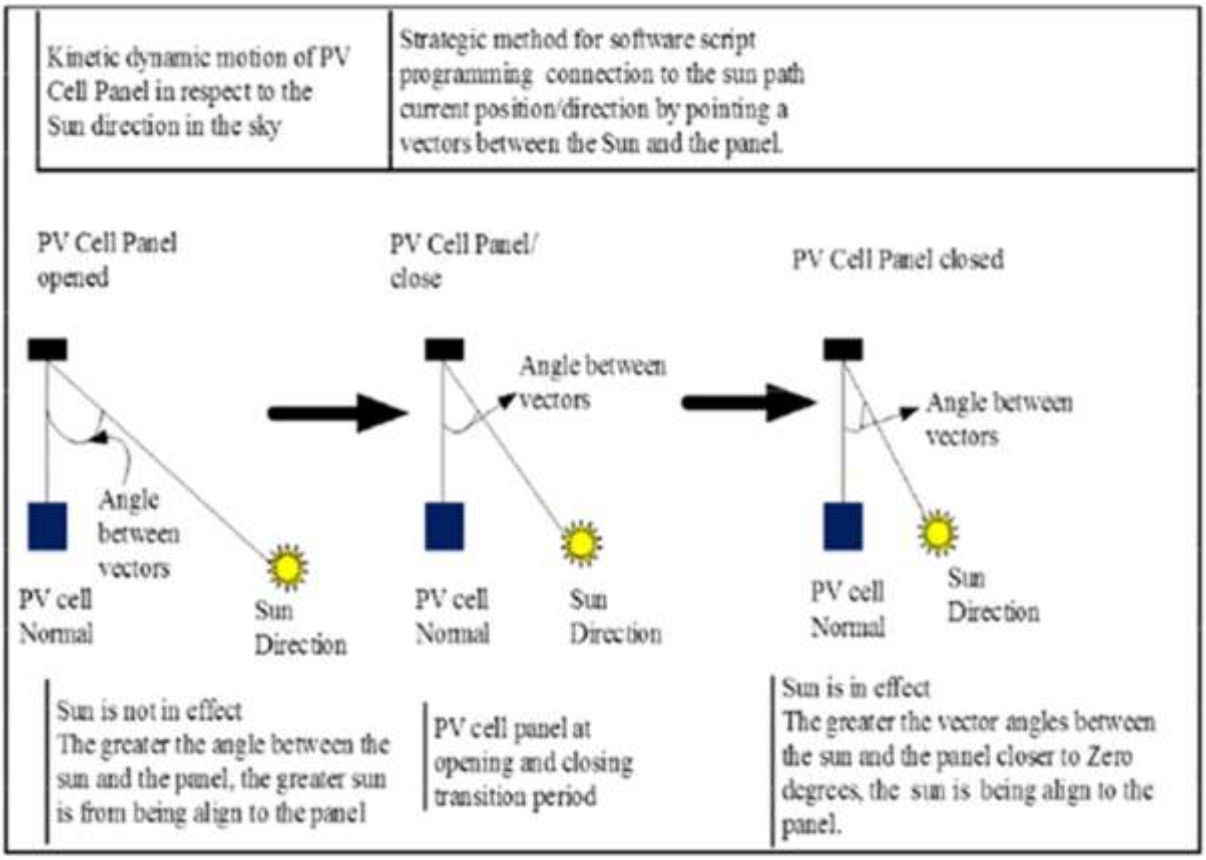


Figure 12. PV cell panel, sunlight effect influence

2.17. PV cell simulation analysis

As mentioned previously, the highest efficiency of PV cell currently in the market without using boosting mechanism to increase its efficiency is in the range of 15to %27, and this efficiency is not very satisfactory. A current literature review of PV cell efficiency articles shows that a number of different methods have been attempted to improve the efficiency of PV cells, one of which is sunlight intensity tracking system and this method has significantly proved the PV cell efficiency. Nevertheless, this is a significant clever method. However, this type of method is not cost-effective. Thus, this research thesis chapter deals and develops a method that works on similar concepts of the sunlight tracking system, but using a cost-effective method, and produces the same or close to the same amount of efficiency. In this method, the PV cell panels are simulated by the Autodesk Revit and Dynamo software application algorism to follow the sunlight irradiation intensity direction once the Sun is above the horizon using natural phenomenon, as shown in Figures 13 to 15. The method costs the minimum, and the cost could be negligible if compared with the other similar methods that produce similar results.

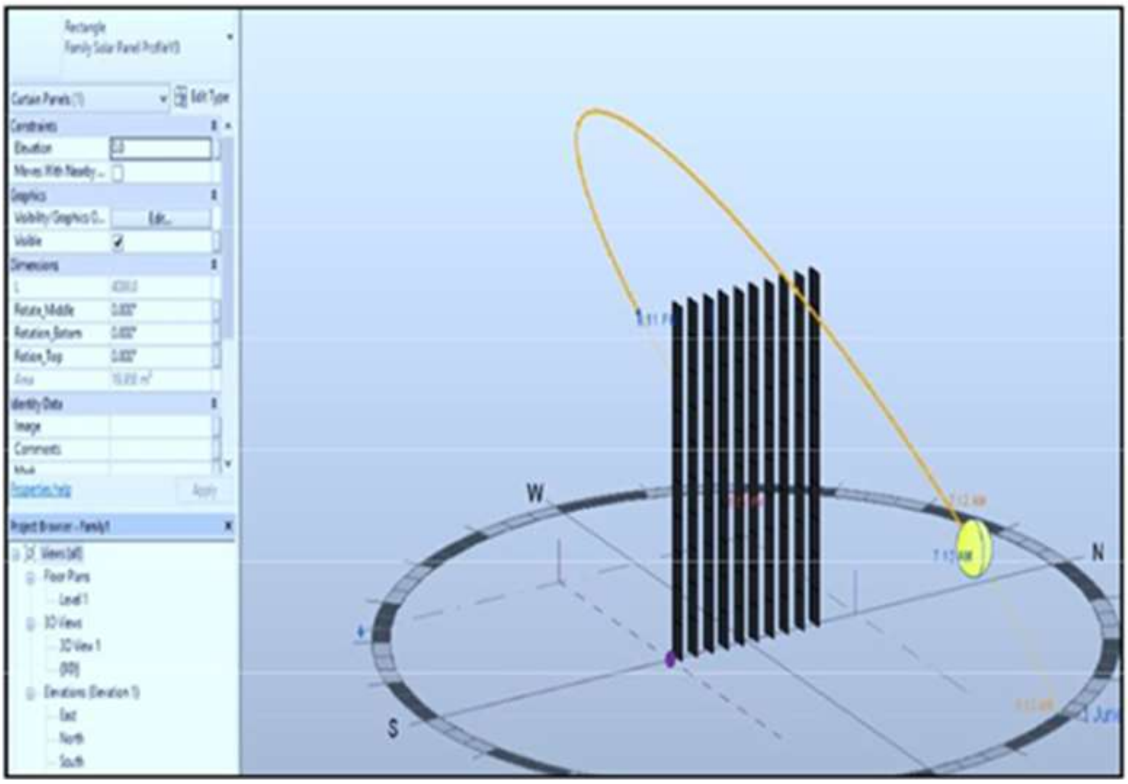


Figure 13. PV cell parameter respond performance during morning hours.

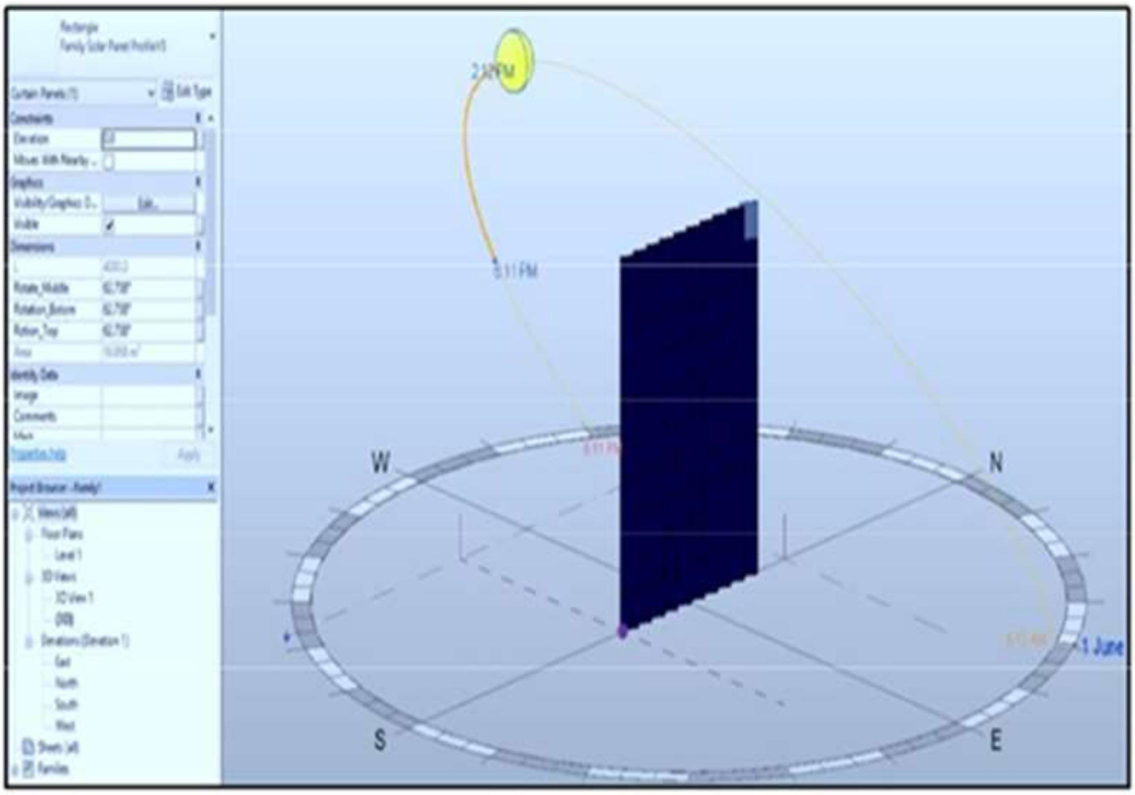


Figure 14. PV cell parameter respond performance during midday hours.

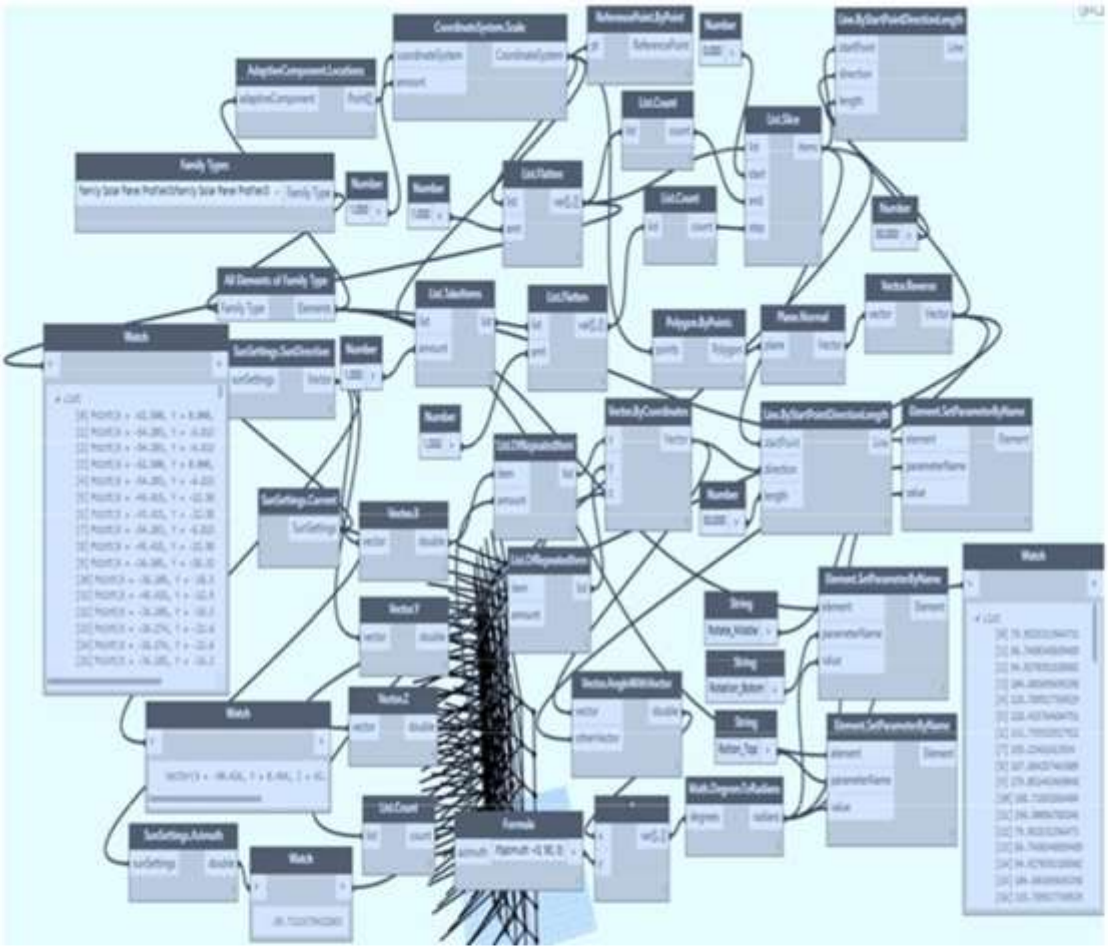


Figure 15. PV cell panel and simulated vectors aligning/misaligning with the sun position, and direction on the sky.

3. Conclusion

Base run building energy simulation analysis covers the second main simulation part. The simulation processes simulate all the building elements for their capability of being energy efficient. However, the simulation results of this section revealed that base run simulation did not reduce energy usage. Furthermore, this section focuses on optimal use of renewable energy with minimal resource consumption in the pre-planning of energy efficient GBs.

As we all know, renewable energy is a key solution to addressing energy costs, shortages of sustainable energy supplies, and global climate pollution from fossil petroleum and other similar substances. By increasing the productivity of renewable energies through their optimized use, fossil petroleum use can be eliminated in the long term. Therefore, three types of PV cell efficiency are proposed for buildings in this section, classified as low, medium and high (%5, %10 and %15 respectively). Solar intensity tracking method improves 15% PV cell efficiency to 40%.

4. References

Alwaer, H., & Clements-Croome, D. J. (2010). Key performance indicators (KPIs) and priority setting in using the multi-attribute approach for assessing sustainable intelligent buildings. Building and Environment, 45, 799-807.

Berman, E. S. F., Fladeland, M., Liem, J., Kolyer, R., & Gupta, M. (2012). Greenhouse gas analyzer for measurements of carbon dioxide, methane, and water vapor aboard an unmanned aerial vehicle. Sensors & Actuators: B. Chemical, 169, 128-135.

Chan, K. (2007). Integrating traditional commercial buildings with intelligent building concepts. Cost Engineering, 49, 25-36.

Gadakari, T., Mushatat, S., & Newman, R. (2014). Intelligent buildings: Key to achieving total sustainability in the built environment. Journal of Engineering, Project & Production Management, 4, 2-16.

Guirguis, D., Romero, D. A., & Amon, C. H. (2016). Toward efficient optimization of wind farm layouts: Utilizing exact gradient information. Applied Energy, 179, 110-123.

Günel, G. (2016). What is carbon dioxide? When is carbon dioxide? PoLAR: Political & Legal Anthropology Review, 39, 33-45.

Kuo, C. F. J., Lin, C. H., & Hsu, M. W. (2016). Analysis of intelligent green building policy and developing status in Taiwan. Energy Policy, 95, 291-303.

Kwon, H. J., Yeon, S. H., Lee, K. H., & Lee, K. H. (2018). Evaluation of building energy saving through the development of venetian blinds' optimal control algorithm according to the orientation and window-to-wall ratio. International Journal of Thermophysics, 39, 1-27.

Lilis, G., Conus, G., Asadi, N., & Kayal, M. (2016). Towards the next generation of intelligent building: An assessment study of current automation and future IoT-based systems with a proposal for transitional design. Sustainable Cities and Society.

Lin, B., & Ahmad, I. (2016). Analysis of energy-related carbon dioxide emission and reduction potential in Pakistan. Journal of Cleaner Production.

Mehta, D. P., & Wiesehan, M. (2013). Sustainable energy in building systems. Procedia Computer Science, 19, 628-635.

Milovanovic, D., Babic, M., Jovicic, N., & Gordic, D. (2012, November). Energy efficiency in buildings, industry and transportation. In AIP Conference Proceedings (Vol. 1499, No. 1, pp. 71-82). American Institute of Physics.

Mláček, M. (2016). Knowledge formalization of intelligent building. AIP Conference Proceedings, 1738, 120005-1-120005-4.

Sherif, A., Sabry, H., & Rakha, T. (2012). External perforated Solar Screens for daylighting in residential desert buildings: Identification of minimum perforation percentages. Solar Energy, 86(6), 1929-1940.

Tih-Ju, C., An-Pi, C., Chao-Lung, H., & Jyh-Dong, L. (2014). Intelligent green buildings project scope definition using project definition rating index (PDRI). Procedia Economics and Finance, 18, 17-24.

Wang, S., Xu, Z., Li, H., Hong, J., & Shi, W. Z. (2004). Investigation on intelligent building standard communication protocols and application of IT technologies. Automation in construction, 13(5), 607-619.

Wong, J., & Li, H. (2006). Development of a conceptual model for the selection of intelligent building systems. Building and Environment, 41, 1106-1123.

Zhu, L., Hurt, R., Correia, D., & Boehm, R. (2009). Detailed energy saving performance analyses on thermal mass walls demonstrated in a zero-energy house. Energy and buildings, 41(3), 303-310.