Department of Electrical Engineering
Assignment
Date: 20/04/2020

Course Details

Course Title:	Direct Energy Conversions	**Module:**	3rd semester
Instructor:	Engr.Shayan Tariq Jan	**Total Marks:**	30

Total Pages:08

Student Details

Name:	MajidFeroz	**Student ID:**	15496

Note: Plagiarism of more than 20% will result in negative marking.
Similar answers of students will result in cancellation of the answer for all parties.

Q1.	(a)	In Renewable Energy Systems Solar Photo Voltaic and Fuels Cell are among the popular choice of technologies used for Direct Energy Conversion. For your home town of (State your city), which will be the better option to power a 10 KW load. Explain your answer based on its pros & cons, users, applications, availability and market. Back your reasons with valid data, facts and figures.	Marks 10
Q2.	(a)	PV Cells performance is greatly affected by a location's climate factors which include irradiance, temperature, humidity and wind. Different locations have different climate conditions. For your home town of (State your city and climate conditions), based on its average climate conditions what techniques will you apply to a PV cell to reduce the effects of climate on the cells performance, reduce losses and increase efficiency. Back your reasons with valid data, facts and figures.	Marks 10
Q3.	(a)	Fuel Cells have many types based on temperature, electrolyte and fuel. What would be the best option and the worst option among the types of fuel cell for providing power to Iqra National University (Take the last 3 digits of your student ID to be the average load KW of INU) located in Peshawar. Explain your choices based on the pros & cons, applications, availability and market. Back your reasons with valid data, facts and figures.	Marks 10

ANSWER NO 1:

Being the resident of Mardan, Khyber PakhtunKhawa. It is evident from the facts and figures and over all Meteorological conditions that Solar Photo Voltaic has an edge over Fuel Cells. In case of photovoltaic cell it only have the huge capital cost which has a very less payback period, its user friendly, environmental friendly, do not produce any by product, easily available, which in case of fuel cell of better efficiency is not available locally and in remote areas. So for that reason Photovoltaic cell is the best source of energy in remote areas. Discussing the inner chemistry of these two, in Fuel Cells formation of hydrogen is itself a difficult job for that reason it can't be used on regular basis while in case of photo voltaic cell the process of electricity generation that is flow of electrons from the outer most shell of doped atoms is easy.

For powering a 10kW load it's preferable to use an on-grid photo voltaic system which consists of the following equipment's:

1. 660 square feet of flat roof space for a **10kW**
2. 35 Photovoltaic Modules each of 330W, VOC = 45, Vmp = 37.5, Isc = 9.1A, Imp=8.87A.
3. 4mm^2 Flexible Cable, double insulation, the reason for selection of 4mm^2 for single photovoltaic module is that each copper conductor of 1mm^2 can carry a current of 2.5A so: The Line Current of 1PV Module is: 9.1 so it becomes 9.1/2.5 = 3.64mm^2, the availability in market in this range is 4mm^2.
4. Combiner box for combining the strings and feeding them to the inverter.
5. DC isolator to isolate the PV String from the rest of system in case of emergency.
6. DC String fuses.
7. Inverter 12 or 15kW as per torque load.
8. Output 440/220Vpure sine wave.
9. Change over Switch in case of WAPDA operation.

PROS OF PV CELL

1. Photovoltaic Modules/cells possess life
2. They are durable
3. User friendly
4. Environmental friendly
5. Low or zero maintenance and labor cost
6. Low payback period
7. Best alternatives of energy source in remote areas
8. No by products
9. Easily available
10. Easy assembling

CONS OF PV CELL

1. Low Efficiency
2. Reduce in energy with the passage of time
3. High Capital Cost
4. Not a constant source of power

USERS AND APPLICATIOS

As a matter of fact people are attracted more to the sun harnessing module and it's easy to handle install and work with. The number of users is increasing day by day and every day the scientists and students are trying their level best to harness more and more sun energy efficiently and to increase the efficiency of the Solar PV Modules. Even the industries are having a hype in this region and many industries around the region, around the world has switched on to this PV Modules. Examples are FCCL 12.5MW Solar Park, Kohinoor Textile Mills - Rawalpindi 3MW Solar Park (2 more in Progress). Interloop 1MW Solar Park, AJ Textile 1MW Solar Park and many more. While Fuel Cell applications and practical examples are rare around the region.

MARKET AVALIABLITY

Even the market is getting hot on new and heavy Solar Inverters, Includes on-grid solar inverters SMA Germany, Huawei KTL for industrial and international market while Inverex and Fronius are playing their part at domestic market.

ANSWER NO 2:

PV Cells performance is affected by a location's climate factors including irradiance, temperature, humidity and wind is undeniable fact. Different locations metrological climate conditions vary time to time.
Home solar panels produces maximum power at **25 °C (77 °F).**Solar panels with an efficiency rating of 17 percent and a temperature coefficient of -0.45, they will lose 0.45% of their efficiency for every degree above 25 °C. If the temperature increases to 30 °C (86 °F), solar panel's efficiency will fall to 16.7 percent. And if it increases to 35 °C (95 °F), efficiency falls to 16.3 percent. Though the temperature condition of my hometown Mardan generally rises above 35℃(°F) in hot summer, due to which the solar panel efficiency reduced by 16 percent.
In order make solar PV efficient the following steps are followed during installation in remote areas.

• Installation of panels a few inches above the roof so convective air flow can cool the panels.

• Moving components like inverters and combiners into the shaded area behind the array.

• Ensure that panels are constructed with light-colored materials, to reduce heat absorption.
Mover over there are some techniques which reduces losses and increases solar PV efficiency which are discussed below.

COOLING TECHNIQUES FOR IMPROVING SOLAR PV EFFICIENCY

Air Cooling Method

The natural air flow is the most common method for cooling the PV panels due to its simplicity, no extra materials being needed, and the cost being relatively low. However, cooling of photovoltaic panels can be improved if on the back of PV panels metallic materials with fins are mounted to ensure a very good air circulation. By using natural air flow between the building vertical walls and PV system mounted on them, the temperature of the photovoltaic panels can be maintained at less than 40° C which is smaller with almost 20° C than the average. The forced air circulation is an active method to cool the photovoltaic panels. There are more methods to force the air circulation, such as open channel beneath, steel plate with an air channel underneath, and array of air ducts underneath the PV panels with optimum fins using the array ducts significantly decrease the temperature of the photovoltaic panels, and their efficiency increases between 12 and 14%.

Water Cooling Method

The temperature of the photovoltaic panels can be reduced using the water which flows on the panels or is sprayed on them. Krauter proposed a method to cool the photovoltaic cell using the water flow on the surface of the panel. The results show that the efficiency of the PV panels increases with 10.3%. The water flow, 4.4 l/min, is achieved using a pump and 12 nozzles placed on the top of the PV panel assuring the distribution of the water. The photovoltaic cell temperature decreases up to 22°C which increases the lifetime of the PV panels. The water film reduces the reflection by 2-3.6%. The gain of the system is 9% if the pump consumption is taken into account.

PCM Method

The phase change materials (PCM) have the properties to absorb the excess heat and maintain the PV panels at constant and uniform temperature. There are different PCM materials able to reduce the temperature of the PV panels and to ensure a homogenous distribution of the heat on all photovoltaic panel surface.

MPPT Method

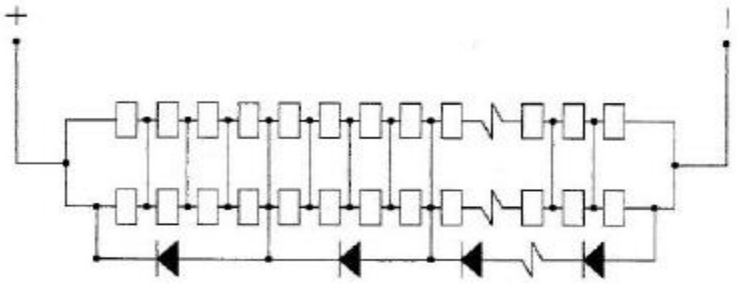
In order to make maximum use of the output of the PV panels, the DC load has to intersect the current voltage characteristic in the maximum power point. In real operation conditions, this rarely happens due to the load mismatch, the variation of the solar radiation, and temperature. This problem can be overcome by using DC/DC or DC/AC converter with MPP controller.

OTHER CLIMATIC EFFECTS WHICH REDUCES SOLAR PV EFFICIENCY AND TECHNIQUES WHICH REDUCES THESE EFFECTS ARE AS DISSCUSED BELOW:

EFFECT OF CLOUDS

It is observed that when the weather is cloudy the PV module power drops and ultimately the load can't be carried in a smooth order which can ultimately makes the load dead.

This problem can be solved by adding a diode in series with that of the PV modules so that when the clouds approaches the system do not receives a sudden jerk and the diodes maintain a safe energy with holding in the line with can be shown in the figure given below



Shading by soiling on PV performance

The term 'soiling' is used to describe the accumulation of snow, dirt, dust, leaves, pollen, and bird droppings on PV panels. The performance of a PV module decreases by surface soiling, and the PV power loss increases with an increase in the quantity of soil on the PV module. Thus, the accumulation of soil on the PV module can lead to a significant decrease in energy produced by the PV module. To overcome the problem of soiling the PV module is properly cleaned and washed by water.

EFFECT OF HUMIDITY

Humidity can slow efficiency in two ways.

1. Tiny water droplets, or water vapor, can collect on solar panels (like beads of sweat) and reflect or refract sunlight away from solar cells. This reduces the amount of sunlight hitting them and producing electricity.
2. Consistent hot, humid weather can degrade the solar panels themselves over their lifetime. This is true for both crystalline silicon cells and thin film modules, but cadmium telluride (thin film) solar cells perform about 5 percent better in tropical climates.

This mainly applies to areas that are constantly humid. Regions with tropical climates, such as Karachi, would be a good example. If you live in Karachi, this probably doesn't come as a surprise.

Solar panel manufacturers are well aware of the effects humidity has on solar panels in humid areas. There are precautions to prevent humidity from deteriorating solar panels faster, such as edge sealants and using low ionic conductive materials.

EFFECT OF WIND

Photovoltaic panel outputs (short circuit current and open circuit voltage) and solar intensity are favoured by increase in wind speed when the wind is towards the position of observer's (or panel's) front with the sun some distance away in front of the observer or when the wind's direction is towards the back of the observer (or panel) with the sun behind the observer (or panel), but unfavorable when the wind is towards the position of the front of the observer (or panel) and the sun is some distance behind the observer (or panel) or the wind's direction is towards the back of the observer (or panel) and the sun is in front of the observer (or panel). For short, under same weather conditions, solar illuminance/intensity is favoured when the direction of the propagation of the solar photonic particles are in phase with the molecular particles of the wind and unfavoured when out of phase. Similarly under similar weather conditions, the output of a photovoltaic panel is favoured when the propagation of the solar photonic particles are in phase with the molecular particles of the wind and unfavoured when out of phase.

OTHER METHODS WHICH REDUCES LOSSES AND INCRESAE SOLAR EFFICIENCY ARE

1) Sun Tracker Systems:

Theoretically, the solar radiation falling on the PV panels increases by 41% when the dual axis sun tracker is used, but the increase in generated energy varies between 10% and 45% in comparison with fixed systems. The energy consumed by the PV system to follow the sun when the tracking system is used varies between 2% and 5% from the generated energy.

2) Putting anti-reflection coasting on the solar cell surface;

3) Texturing front surface to reduce reflection;

4) Minimizing the front metal contact coverage area to reduce contact shading; and

5) Making solar cell thicker to increase absorption of low energy photons

ANSWER NO 3:

FUEL CELL:

Is an Electrochemical energy conversion device which converts the chemicals hydrogen and oxygen into water.

Generates electricity by a chemical reaction.

Every fuel cell has two electrodes, one positive and one negative, cathode and anode respectively. The reactions that produce electricity take place at the electrodes.

TYPES OF FUEL CELLS

Polymer Electrolyte Membrane (PEM)

Operating Temperature: 50-100℃ Typically 80℃
Typical stack size: <1KW-100KW
Efficiency: 60% Transportation and 35% stationary

Alkaline (AFC)

Operating Temperature: 90-100℃
Typical stack size: 10KW -100KW
Efficiency: 60%

Phosphoric-acid fuel cell (PAFC)

Operating Temperature: 150-200℃
Typical stack size: 100KW-400KW
Efficiency: 40%

Molten carbonate fuel cell (MCFC)

Operating Temperature: 600-700℃
Typical stack size: 300KW -3MW
Efficiency: 45%-50%

Solid oxide fuel cell (SOFC)

Operating Temperature: 700-1000℃
Typical stack size: 1KW -2MW
Efficiency: 60%

BEST OPTION

Solid oxide fuel cell (SOFC)

As the average load according to last digits three of my ID is **496KW.**

Hence the only choices for me according to load are molten carbonate fuel cell (MCFC) and Solid oxide fuel cell (SOFC). So in my opinion the best option for me to choose fuel cell for 496KW load is Solid oxide fuel cell (SOFC) due to following reasons.

Compared to the other fuel cell technologies SOFCs presents the following advantages:

- Thanks to the high temperatures a wide array of different fuels containing hydrogen (coal gas, bio gas, propane, natural gas, and hydrogen) can be used since the fuel reforming takes place directly inside the cell.
- The highest electric and thermal efficiency (up to 80%) with combined heath systems) among all the fuel cells.
- No need to use noble metals as catalysts inside the cell other expensive materials.
- Possibility to use many different low cost hydrocarbon fuels (biogas, coal gas, natural gas).
- A long operative life cycle due to the low degradation of the materials
- The structural simplicity of the cell permits the simplification of the production lines.
- Very low emissions both in terms of NOx and SOx if the cell is supplied with hydrocarbon fuels (zero emissions if the cell is supplied with pure hydrogen).
- Low noise production system.
- SOFC detain a very good power efficiency, near 60%, a long term performance stability and a high thermal efficiency.

APPLICATIONS

- Auxiliary power
- Electric Utilities
- Distributed generation

WORST OPTION

Polymer Electrolyte Membrane (PEM)

The worst option which I assumed from above given data is Polymer Electrolyte Membrane (PEM) due to following reasons.
PEM Fuel cells catalysts are susceptible to CO poisoning due to their low operating temperature. Therefore, the CO concentration has to be reduced below 10 ppm with CO removal if the reformate from hydrocarbons or alcohols is used as a fuel for the PEM fuel cells.
The temperature of recovered waste heat is lower than that of other fuel cells.
As result recovered heat can be utilized only as hot water.
Moreover the Polymer Electrolyte Membrane (PEM) is more expensive and sensitive to fuel impurities nor it fulfill the requirement of 496kw load.