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

Course Details

Course Title: Direct Energy Conversions **Module:** 3rd
Instructor: Engrshayantariq **Total Marks:** 30

Student Details

Name: Mamoon khan **Student ID:** 15628

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 optionamong 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

Q1. (a) Answer: **ID: 15628 MS (EE)**

As we know that 10kw system is on large side for Residential installation (5kw System is more common). As i belong to District swat and because of the balanced weather thus the 10kw installation will be more appropriate for my city we will have good choice for homes having low electricity consumption and want to go off grid. So solar PV and fuel cells installation will be the best alternative option for our 10kwload. To go for installation we need to analyze it first.

Solar Panels Required: 10kw solar system will required about 25-30 panels and the required area for this installation will be 40-70 meter square. It depends on the power wattage of panels.

Depends on Number of factor power output may vary:

1. Panels location and climate of that area (Swat District is quite different and unbalance its varies day by day)
2. Angle of solar panels.
3. Shades on some areas of panels (shade may reduce the power).
4. Operating temperature.
5. Solar panels and inverters capacity, performance of panels and inverters.
6. Backup or Fuel cells the main reason.

Pro:

Solar PV is a renewable energy source Reduce electricity billing.

Lowe maintenance cost.

It is technology development source marginal cost of generation is zero.

Diverse application.

Cons:

High initial cost.

Depends on weather.

Use allot of space.

Not good if u are planning to move.

User:

Use for heating the building, cooking and electricity production.

Use for solar lighting (many countries using this technique.

Availability:

As huge amount of sun light comes to the earth half of it reflect the atmosphere. As it is a great source of energy and its availability is constant many develop countries are using this technology.

Market:

Solar has given the 2nd number addition in each of last year. 40% of electricity is added to the grid which is from solar energy. Large amount of energy so solar is increasing rapidly instead of other technologies. And the market availability of solar PV and Fuel cells is present easily at low cost in market.

Fuel Cell:

It coverts chemical energy to electrical energy. It converts chemical hydrogen and oxygen into water. It generates electricity by chemical reactions.

Better option to power the Load: As mentioned about the load 10kw and the weather condition of District swat we have to select the better option of fuel cell to power the load easily.

We have different type of fuel cell but according to my point of view the Best option for the above condition will be.

Polymer Electrolyte membrane (PEM):

PEM use a water-based or mineral-acid based polymer membrane as an electrolyte and platinum group based electrodes. The water based PEM fuel cells operate at 80-100C. it hastypically as stack size of 1kw-100kw this will be more suitable for our 10kw load because of our city load condition (is very low) and as we are gifted by God with a pleasant weather. According to this condition the PEM will be more suitable for my City as it match the requirement which I need. It is used more for transportation60% and has stationary Efficiency of 35-40%. They required precise humidity conditions to operate and their acidic nature requires the use of platinum catalyst. They are relatively small and light in weight. According to load stack numbers are increase.

Pros:

1. Quick start up
2. Small in size
3. Light weight
4. Low temperature
5. Reduce corrosion & electrolyte management problems.

Cons:

1. Sensitivity to dryness
2. Sensitivity to fuel impurities
3. Sensitivity to low temperature waste heat
4. Expensive catalysts

Uses: it is widely used in

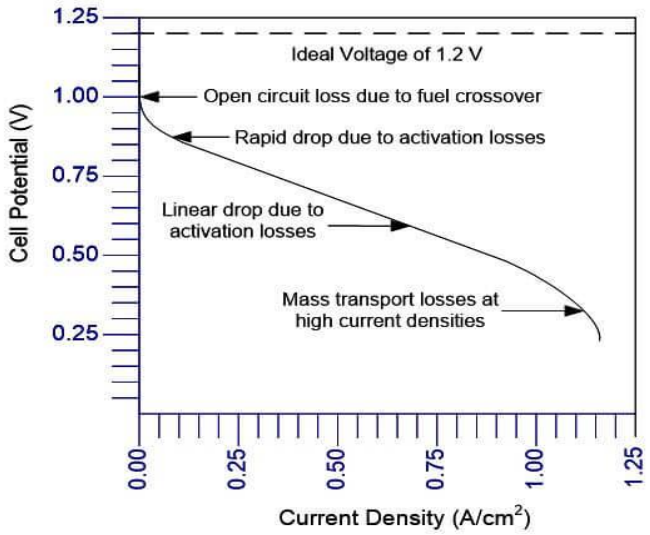
1. Car
2. Buses
3. Truck
4. For homes electricity (very suitable to 5kw load)

Application:

1. Portable power
2. Backup power
3. Transportation Applications
4. Automobiles
5. Buses
6. Utility
7. Stationary power applications

Fuel Cell Performance Graph:

By this polarization Curve they will allow you to calculate the overall performance. An example figure is shown below.



1. At low temperature the cell potential drop due to active polarization.
2. At moderate current densities, the cell potential decreases linearly with current due to ohmic losses.
3. At high current densities, the cell potential drop departs from the linear relationship with current density due to concentration polarization.

We can generate the polarization curve which will not match the actual polarization curve for the fuel cell stack but module may need to be improved with more accurate way of accounting the phenomena that is occurring in the fuel. It mean that how a fuel cell can be constructed using electro chemistry concept.

In my point of view the above options (PV and fuel Cell) are the best according to my analysis for my city Swat and its weather conditions.

Q:2 (a) Answer:

As I mentioned in previous Q1 my home town is (Swat). As we know that swat is one of the most Deferent weather condition weather can change easily .

Still here is a big problem of electricity so people are going towards new ideas like solar PV. Most of homes is using the Solar technology especially in the mountains areas where no electricity is provided by WAPDA.

As PV system generates electricity based on the amount of sun light they receive. Here I will discuss the climate factors of our area.

Climate Factor:

The installer should understand the type of local wind Factor and climate condition of the area to pick right solar panel to match these conditions.

1. **Shaded Area:**when a solar cell is shaded the current through the entire string is reduced. This is because every cell in the cell string has to operate the current set by shaded cell this prevent the un shaded cell from operating at maximum power.Therefor only small shades have a dramatic effect on the power output.

2. **Temperature effect:** Extremely hot climate can cause solar panel to overheat and become inefficient in the same way other electrical devices over heat in hot weather so it requires the balance temperature to operate efficiently.
3. **Wind:** wind and rain has also an effect on the solar PV. Wind can affect the panels if it is not fitted with good support it can damage the panels and can reduce or completely cutoff the supply.
4. **Rain:** Rain has both good and bad effect on the Solar PV System. Bad effect is that it can reduce the supply If it constantly raining for a long time.

   Good Effect is that it clear the dust from the Solar Panels installed and it works efficiently.
5. **Angle :**whenever to install a solar PV make in consideration about the installation angle Install the panel to the angle to the sunlight in your location.

Taking these points in consideration about these points some technique can be applied.

Techniques to reduce the effect of these factors:

1. **Shading:** Different techniques appalling to reduce the effect of shading and to increase the efficiency.
   1. String Arrangement: Module connected in series from string and string can be connected in parallel to the inverter. The current through all the modules of a string has to be same and voltage of parallel string has to be the same a shaded module one string does not reduce the power output of a parallel string. Therefore by grouping shaded modules into separate strings. The overall power output of the array can be maximized.
   2. By Pass Diode:Bypass diode are diode within a module that allow the current to skip over shaded region of the module.
   3. Module level power Electronic: it is a device that is attached to individual module in order to increase performance under shaded condition.
   4. Dc Optimizer:A Dc optimizer adjusts its output voltage and current to maintain maximum power without compromising the performance of the modules. If a shade reduces the current a dc optimizer will boot the current to cover it.
   5. Micro inverters: Each panel can have a small inverter attached to it to convert it output from Dc Current to AC Current it has MPPT and connected in parallel. Each will operate its maximum power point without impacting the other panels.
2. **Temperature:** In our city SWAT there is not much an issue of temperature as it is normal and very pleasant temperature trough out the year. The temperature is suitable for Solar PV and it will not affect the system here.
3. **Wind:**Swat is most of hilly area so there is not much Wind or hurricane the wind flow is normal in in accordance of other part of the country. For our PV safety we have to fix the Panels tightly through different types of stand.

4. **Rain:** Rain is what which can affect the power continuity if it constantly raining for a long time for this problem to fix it we will provide batteries with good backup time to reduce the effect of the rain on the PV system. Here fuel cell will be the best choice which will provide backup to the system we will chose best fuel cell according to our criteria and to reduce the losses this is the best choice.
5. **Angle:** Angle to the sun light is most important in PV installation the installer should have knowledge to place it an angle to sunlight correctly the more sun light it receives the more will be the output and accurate. It will reduce the losses when it placed in a good angle.

The Above Condition can affect the PV Cells and the above technique we can apply to reduce the losses occur due to above Climate condition. As an engineer to install PV system we can have these things in mind.

Q 3: (a) Answer:

As we know that fuel cells have many types according to specification. Here we have to select the fuel cell for a load of 628kw of INU. First we have to discuss the best option of a fuel cell for providing power to INU.According to my analysis and opinion Phosphoric Acid (PAFC). Is the best option to provide power to INU. Her I am explaining my point with some facts.

1. **Phosphoric Acid Fuel Cell:**
   Phosphoric acid fuel cell is the best option currently using worldwide for Building, Hospitals, Hotels and areas where continuity of power needed. Due to its high reliability according to other fuel cells and it is one of the most mature types of fuel cell and the first one commercially used so we are using it to power INU. It has an operating temperature of 100-200C. It has the efficiency of 37 to 40% plus efficiency alone and 85% when it is used in combination of heat and application. It is typically used for Distributed generation (DG) application which provides primary power and heat facility. They are large fuel cells which provide about 100kw-400kw of power and more tolerant of fuel impurities then polymer electrolyte membrane fuel cell.
   Existing phosphoric Cells of output up to 200kw and on large scale 1Mw and 5Mw unit have been tested. Liquid phosphorus use as electrolyte, hydrogen oxygen water, solid electrolyte.
   Water management in these fuel cells is easier than PEMs, and they are more tolerant of impurities in hydrogen.

Pros:

1. More tested for Buildings with Great Efficiency.
2. Fuel flexibility (including natural gas).
3. Operating at 40% plus efficiency alone and 85% in combination.
4. Increase tolerance to fuel impurities.
5. High temp enables CHP.

Cons:

1. Long startup time.
2. Pt. catalyst.
3. Low current and power.

Applications:

1. Distributed generation DG.

Availability:

PAFC is available world wise in a qualitative cost. It is available and its installation in a building has goo effects on power stability.

Market:

Rising demand for clean energy worldwide is set the propel the growth of this market in the foreseeable future. According to the (IEA), global energy demand will increase unhindered at 1.3% annually till 2040. Nearly 50% will come from renewable energy sources. And they stated that PEFC has foreseen to play a vital role in this regard. PAFC can be a game changer in power generation as when it is used with co-generation it goes over 85% efficiency. As many countries are using this technology USA, JAPAN, GERMANY and many other countries.

Worst Options:

In my point of view except (PAFC) all other are not suitable for building of INU to Power it. Because they all are not fit for the requirement of INU needed to power the campus.we are discussing all one by one.

PEM:

1. As PEM has low stack size.
2. It has expensive catalyst.
3. Sensitive to fuel impurities.
4. Cell output is not in much range which is not suitable for Heavy loads.

AFC:

1. Its efficiency is low.
2. It is sensitive to CO2, fuel and air.
3. Electrolyte management.
4. It has not much output range to go for heavy loads.

Molten MCFC:

1. It has very high temp corrosion and breakdown. This is not possible in low buildings.
2. Long start time it takes and having low power density.

Solid Oxide (SOFC):

1. It has a high temp corrosion and breakdown of cell components which is not possible in building power as it requires very high steps.
2. High temp operation requires
3. Long startup time and limit.
4. It capacity is very large it is no suitable in a campus.

How can we increase the performance of our installation?

Issues with the primary power source or situations which lead to the intentional shut down, for example as a result of Hurricane, wildfires and other extreme weather conditions, if we need more time then we need to installs more batteries? Or we will install diesel generator however they are highly polluting and noisy need regular maintenance and or often not permitted in residential areas. This is leading many utilities to explore alternative Ups. A backup might you say. And hydrogen fuel cell is offering a very compelling business case. Contrary to storing chemical energy like battery, a fuel cell actually generate energy itself.In fact fuel cell can continuously generate electricity as long as they are supplied with fuel (hydrogen) and oxygen. Its offering a fail-safe solution which can support current requirements. Fuel cell generators operate as a direct backup power supply.

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