IQRA NATIONAL UNIVERSITY

Department of Electrical Engineering

DEC ASSIGNMENT

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Program: MS (EL.E)

Semester: 3rd

Subject: DIRECT ENERGY CONVERSION

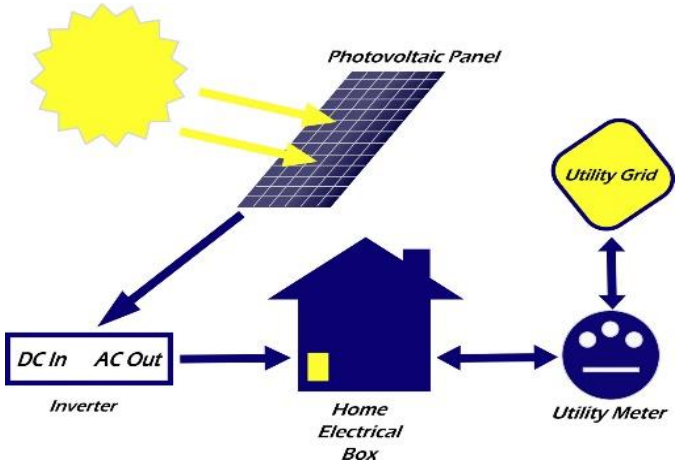
Submitted To: Engr. Shayan Tariq Jan

Submission Date: 28 April 2020

Q 1: In Renewable Energy Systems Solar Photo Voltaic and Fuels Cell are among the popular choice of technologies used for Direct Energy Conversion. For your hometown 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.

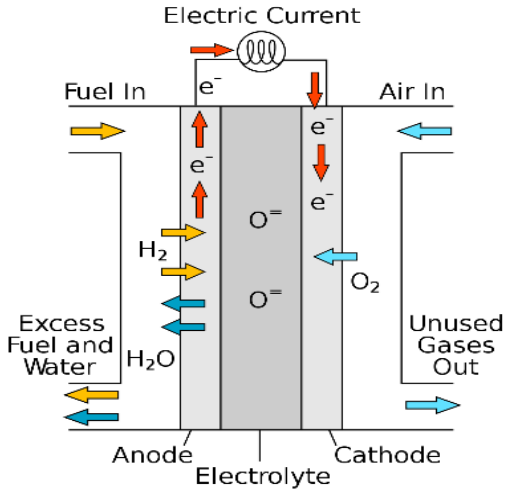
Answer:

Solar Photo Voltaic: It is a semi-conductor device, which converts sunlight (solar radiation) into useful electric energy by the method of photovoltaic effect for home appliances or other electric appliances by means of solar panel.



PHOTOVOLTAIC SYSTEM

Fuels Cell: It is an electrochemical device, which converts chemical energy of fuel into electrical energy by method of chemical reaction.



FUEL CELL

PROS & CONS:

PHOTOVOLATICS	FUEL CELLS
Energy can be stored in batteries	It was deign to use instead of batteries and engines
Structure have three main parts: N-Layers, Junction and P-layer	Structure have four main parts: Anode,Catalyst,Cathide,Electrolyte
Voltaic Cell	Electrolytic Cell
Clean Energy	No Pollution
DC Voltage produce	Generate DC voltage
High initial cost	High initial cost
It can generate electricity only during sun hours	Required large amount of energy for starting reaction
Payback period is long	Not easy to store & move from one place to another

APPLICATIONS:

SOLAR PHOTO VOLTIC:

- PV system can be used for home appliances. As a result, utility bills will be reduce in cost.
- We can use it for street lighting. Around 325 MW of electricity is used by street light. If streetlights are powered by PV system, we can save around 325 MW of electricity generated by dams.
- In remote area, where there is no electricity. Agriculture land depends upon water pump and runs by generators. We can use PV system to run water pump as a result cost of fuel can be save.
- In remote area where there is no electricity, we can build small PV grid system to powered small area.
- We can use PV System in car, buses etc. to safe fuel.

FUEL CELLS:

- In remote area, fuel cells are used as backup or primary to supply electricity.
- Some fuel cells produces large amount of energy and used in military application.
- Electronic devices are also powered by fuel cells.
- They are used to run vehicles, clean fuel and eco-friendly.
- They are used to power space programs.

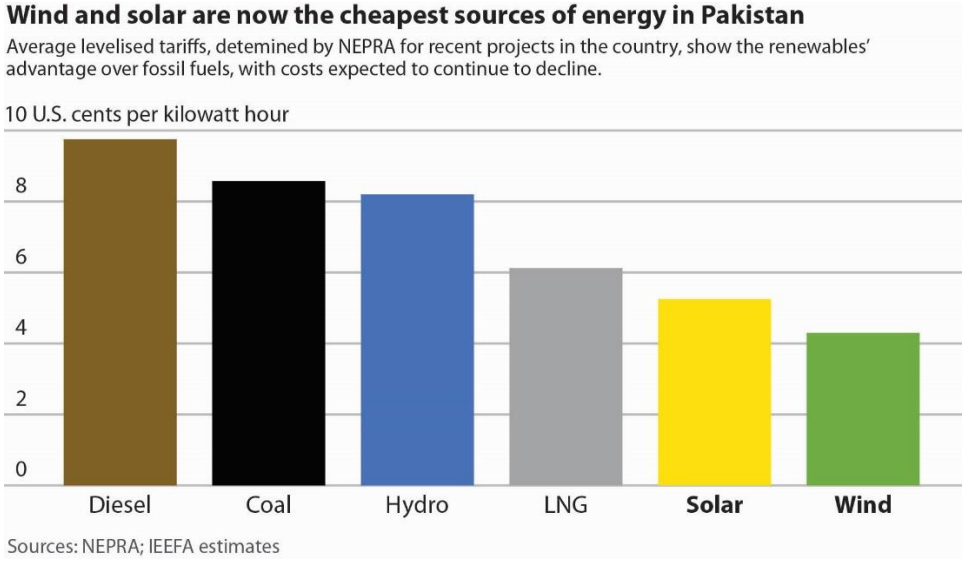
AVAILABILTY & MARKET:

SOLAR PHOTO VOLTIC:

Electricity demand in Pakistan is increasing day by day and our dams cannot fulfill the demand. Pakistan have such climate that sun radiation is high.Govenment is now moving towards renewable sources like PV system to fulfill the energy crisis. In 2014, Pakistan has installed almost 400 MWp by replacing 5% diesel and in 2015, 1000 MWp later added capacity by 600 MWp. The government is trying to produce clean energy and has goal to add 10 GW of renewable capacity by 2030.

In recent years, researchers are trying to make PV panel's cheaper, production easier and small in size, eco-friendly.

Report of 2019, PV panel is manufacture and import on large scale in Paksitan.Everyone is using PV system. It is easily available in market and cheap in rate and save utility bills.



FUEL CELLS:

It is not new technology, but a great source of energy. By 2024, global market of fuel cell can be reach to USD 1060 million, from the 2019 market estimate that is USD 341 million. Its major goal is for power backup. In transport sector, its demand is high because its eco-friendly, small in size.loger lifespans, refuel in minutes. However, disadvantage is that it is not easily available and expensive

Therefore, its main drawback is that it is not easily available in market and its cost a lot.

Application and user:

SOLAR PHOTOVOLTAIC:

As my hometown is Peshawar. Let, we assume that my home load demand is 10 KW.

Load Details:

Load Name	Load Rated Power	QTY	Total Rated Power
LED	11W	20	220W
Fan	80W	4	320W
Laptops	150W	2	300W
Fridge	120W	2	240W
Dispenser	250W	1	250W
Tube Light	150W	1	150W
Dryer	300W	1	300W
Oven	1500W	1	1500W
Electric Pan	300W	2	600W
Split (1.5HP)	1125W	4	4500W
LED TV	25W	1	25W
Receiver	150W	2	300W
Motor	200W	1	200W
Total			8905W

1) **Power consumption** demand of total appliances= 8905 W

Total PV panels energy needed =8905* 1.3

=11576.5 Wh/day

2. Size the PV panel

Total Wp of PV panel capacity needed =11576.5/3.4

=3404.8 Wp

Number of PV panels needed =3404.8/110

=30.9 modules

Actual requirement = 31 modules

So this system should be powered by at least 31 modules of 110 Wp PV module.

3. Inverter sizing

Total Watt of all appliances = 4361 W
For safety, the inverter should be considered 25-30% bigger size.
The inverter size should be about 4400 Watt or greater.

4. Battery sizing

Total appliances use = 8905 Watt
Nominal battery voltage = 12 V
Days of autonomy = 3 days

$$\text{Battery capacity} = \frac{8905 \times 3}{(0.85 \times 0.6 \times 12)}$$

Total Ampere-hours required 4365.1 Ah
For backup battery must be 12 V 4366 Ah for 3 day autonomy.

5. Charge Controller

PV module specification
Pm = 110 Wp
Vm = 16.7 Vdc
Im = 6.6 A
Voc = 20.7 A
Isc = 7.5 A
Solar charge controller rating = (31 strings x 7.5 A) x 1.3 = 302.25 A
For protection of batteries, charge controller must be 310 A at 12 V.

6) Area Required

Area=member of modules/10

=31/10

=3.1 Marla

7. Cost of System

S.No	Item	Rate	Qty	Unit	Total
1	PV Modules (110 W)	75	11576	Watt	868,200
2	Inverter (4400 W)	170,000	1	No	170,000
3	Fixed Mounting Structure	22	11576	Set	254672
4	Batteries (200 Amo)	15000	22	No	330000
5	Cable 3-Core (AC-Wiring)	15000	1	Set	15000
6	Charge Controller	30000	1	No	30000
7	Dc Wiring	125000	1	No	125000
8	Breaker. Safety box, connecter etc.	120000	1	set	120000
9	GST	105400	1	Job	105400
				Total	20,18,275
	Rate Per Watt =	174.3/Watt			

FUEL CELLS:

10 kW Hydrogen Fuel Cell Power Generator

COST:

45000 USD= 72, 43,875 PAK

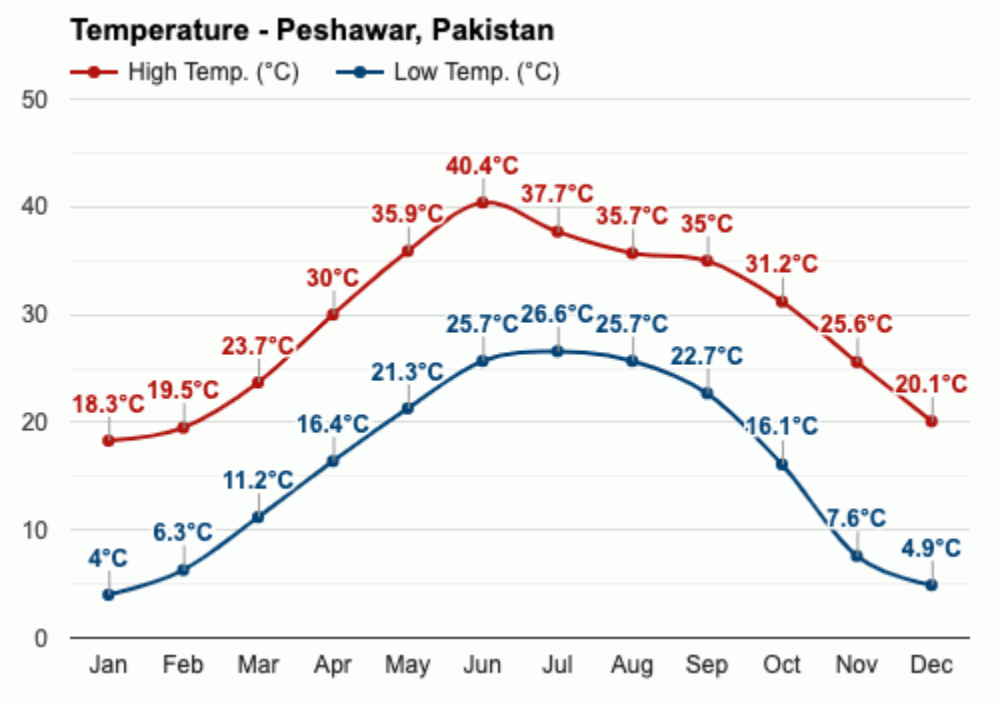
CONCLUSION:

After the analysis, fuel cells are not easily available in market and its cost is much more than PV system. I will prefer PV system for my hometown to power 10 kW load.

Q 2: 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 hometown 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.

ANSWER:

My hometown is Peshawar and its climate condition is shown on following graph:



PV system consist of following main components:

- Panels
- Charge Controller
- Inverter
- Batteries

For better efficiency and minimize losses panel should be selected on the following basis:

1) Solar Panels:

- Solar Panels convert sunlight into electrical energy.
- The Solar panels must be mono crystalline silicon Grade-A Solar cells. (N-Type Mono PV Cell panel because it performs better).
- The Solar Panels must meet the following IEC Standards or latest:
  - IEC 61215:2005
  - IEC61730-1:2004
  - IEC 61730-2:2004
- Panels must have water proof terminal junction box IP65 protection with provision of opening for replacement of DC cables, blocking diodes and easy debugging if necessary

2) Charge Controller:

- Min function of charge controller is to protect the batteries from over charge.
- Operating temperature 0°C to 50°C
- Storage temperature -10°C to 60°C

3) Battery:

- The batteries should be housed in a vented compartment/stand that prevents users from coming in contact with battery terminals.

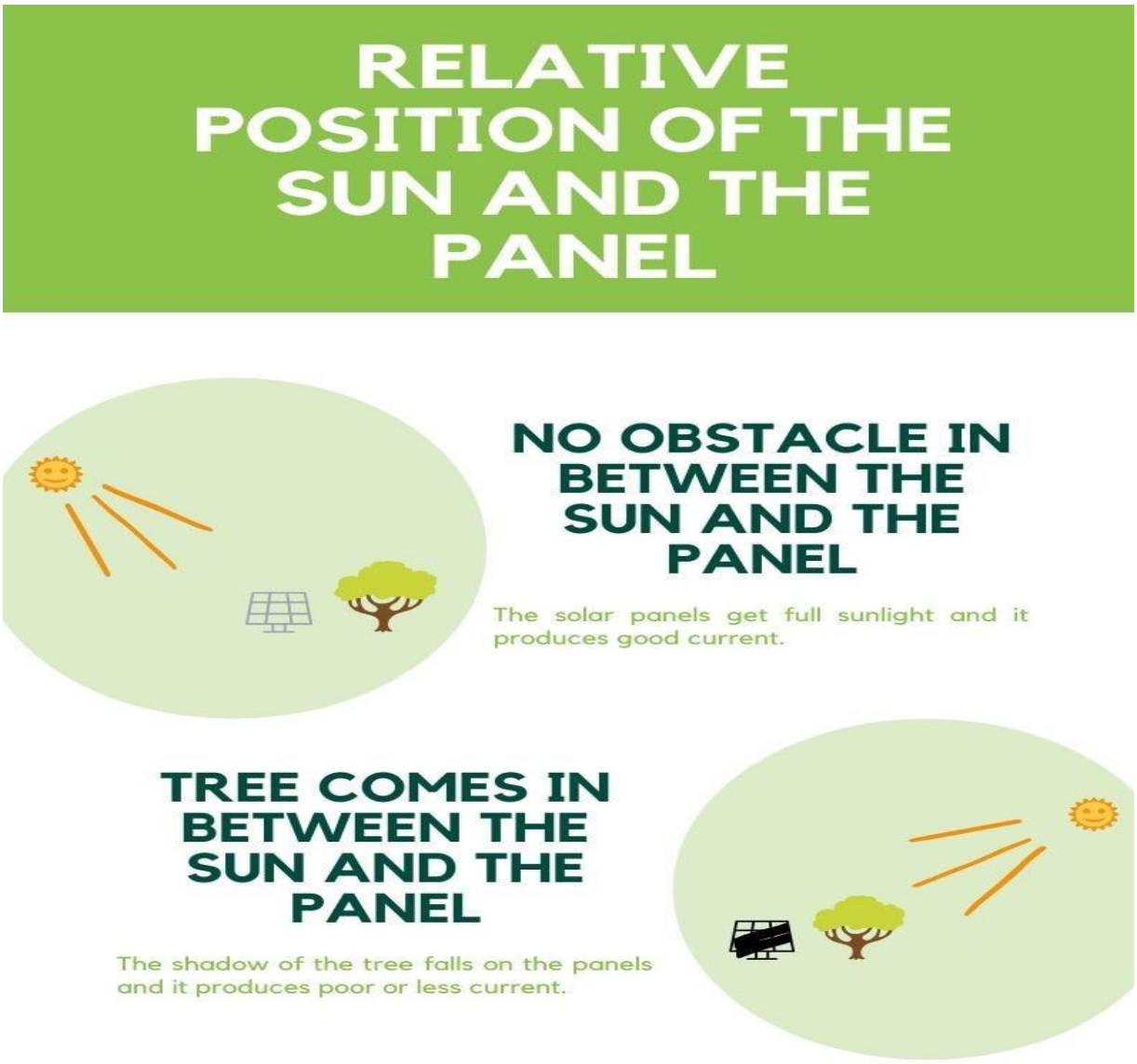
4) Inverter:

- The solar inverter must have Auto MPPT controller and protection against over load.
- Soft start/Soft Stop Features and Variable Frequency Drive (VFD) with integrated Gate Bipolar Transistors (IGBTs) of European, USA or Japanese origin or atleast equivalent.
- The inverter must meet the following standards:
  - CE/RoHS
  - Low Voltage Directive 2014/35/EU
  - EMC Directive 2014/30/EU
  - IEC 62109-1 (Safety of Power Converters for use in PV Systems)
- Inverter circuit must include protection against:
  - Over or Low voltages and currents beyond critical level of the inverters circuits.
  - Can protect system against short circuits.
  - Protection against lightning.

Environmental losses & Protection:

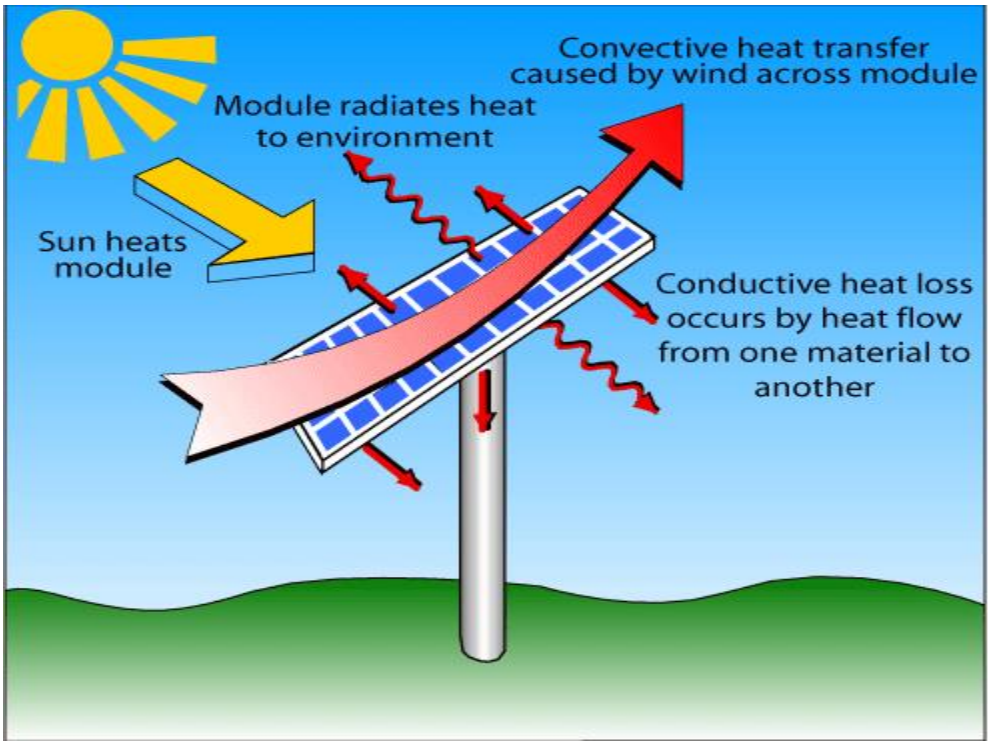
1. **Irradiance:**

   Solar panels have made up off cells, combine together in series to form panel. If solar panels are place under shade, obstacles (tree,buildings,tower etc),sun light cannot fall on each cell of panel and produces less energy. Because after at one point in a day, shadow of obstacles will cover some area of panel.



So, place the panel at such height or place that no obstacles can block the sunlight to fall on panels and can give full efficiency. In addition, always install A-grade panels (Mono crystalline panels).

2. **Temperature:**
   If temperature increase, efficiency of the system will be decrease.

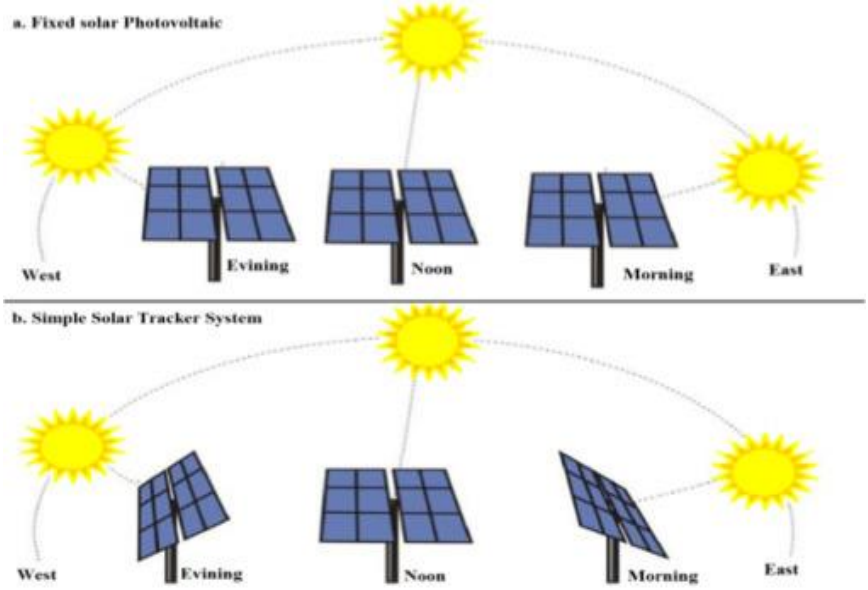


There are different variety of panels.So,before installing the system you have to check the climate condition of your area. And install that panels which are suitable with your area climate. You can check the temperature range at the back side of panel.

3. **Wind:**
   The wind take dirt,dust,leaves,pollen etc. from the ground and leave it over panels.Thes dust form thin layer on the panels, and block the solar radiation and drops the efficiency of the system.

In order to get high efficiency of the system, you have to clean the panels after few weeks.

4. **Design Loss:**
   PV system give maximum efficiency, when sun rays falls overall panels but it is impossible all day sun rays fall on whole panel because earth is revolving. In morning sunrays has one direction and afternoon it has different direction.



To have maximum efficiency, we can install solar tracker instead of fixed PV system. When sun moved its direction solar tracker will also move from east to west to get maximum sun rays.

5. **Humidity::**
   Humidity are small water vapor, that covers the panel and as a result reflect the sun rays, corrosion of metals and fade its color's a result drops the efficiency of system.

Before installing the PV system, always check your area for humidity history and check the backside of panel detail for checking humidity range before buying panels.

Conclusion:

Climate factors affect the PV system cell's performance, energy losses as well as drop efficiency. So, whenever installing PV system always collect data of your area climate and check the backside of panel detail for checking different parameters before buying panels. In this way, your system can increase performance, reduce losses and increase efficiency.

Q 3: 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.

Answer:

Types of fuel cells are:

A. Polymer electrolyte Membrane (PEM)
B. Alkaline (AFC)
C. Phosphoric Acid (PAFC)
D. Molten Carbonate (MCFC)
E. Solid Oxide (SOFC)

Let us take average load of INU is 560 KW, the best option to power INQ is **Molten Carbonate (MCFC) and the worst will be** Phosphoric Acid (PAFC) because of following:

Anode:

- MCFC anode is made up of steel or nickel while PAFC anode is made up of platinum and platinum is expensive than steel.Thats why MCFC is cheap and easily available.

Electrolyte:

- MCFC uses molten carbonate Electrolyte that is solid in nature while PAFC uses phosphoric acid, which is liquid in nature.
- So, MCFC is easily to handle and transport as compared to PAFC.

Fuel:

MCFC has variety of fuels (Natural gas, methanol,ethanol,Biogas and cola gas) while PAFC has only two fuel type (Hydrogen, methanol) that's why MCFC more efficient to use due to variety of fuel availability.

Efficiency:

- MCFC has 45-50 % efficiency while PAFC has 40 % only.

Power:

- MCFC has 300 KW – 3 MW while PAFC has 100 Kw - 400 KW

Startup Time:

- MCFC has starting time 10 min while PAFC has more than 10 min.

Availability and Market:

- MCFC market and availability is more than PAFC because of more variety of fuel availability.
- Also MCFC typical stack size is greater than PAFC and uses on large scale
- MCFC is used more than PAFC due to is better efficiency

Pros & Cons:

- MCFC has more variety of fuels (Natural gas, methanol etc.) while PAFC has only two types of fuels (Hydrogen, methanol).
- MCFC is more efficient than PAFC.
- MCFC upon high temperature enables CHP while PAFC upon high temperature corrosion and breakdown
- MCFC has less start up time as compared to PAFC
- MCFC has more current and power than PAFC

Application:

- MCFC can be used for electric utility and distributed generation while PAFC can only be used for distributed generation
- .

Conclusion:

- Main reason,MCFC is best due to its stack size that is 300 KW – 3 MW and PAFC is worst, stack size 100 KW – 400 KW and our requirement is 560 KW that is fulfill by MCFC.
- Beside this.MCFC is more efficient and more variety of fuel is available as compared to PAFC.