Design and Testing of solar charging stations for Electric Vehicles

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Copyright Statement

Acknowledgement

First and foremost I am highly thankful to almighty Allah for making be able to accomplish this research work because without his help it wouldn't have been possible.

I am grateful to my loving parents for all their support and the way they brought me up and made me able to handle all kinds of pressure and helped me through thick and thin.

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Dedicated to my loving parents, adored siblings and friends whose help

And support made it all possible

Abstract

The fossil fuel reservoirs are diminishing, therefore the world is shifting on alternatives to diminish its dependency on the conventional fossil fuel. One of the most appropriate options is the photovoltaic energy which is sustainable as well as environmentally friendly. So the deployment of the daytime charging of the vehicles will have remarkable impact on the CO2 emission and will also contribute a considerable value to the total energy required for transportation which will support to minimize the stressful usage of the fossil fuels.

In this research a charging station will be designed for the Electric vehicle. A complete energy analysis wis carried out; and charging for Electric bus of 48 volt is tested and analyzed by converting it into solar powered transportation mode. This will reduce the cost of charging the electric vehicle. Analysis of 12 V battery is also done and analyzed battery charging time among solar and Wapda Power charging.

Solar powered transportation mode is the most economical mode in the future and there is a great feasibility of using solar energy for transportation industry. Solar Powered Trains and buses have great potential to be launched in Pakistan to ease the current tension in power industry

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1 CHAPTER 1: INTRODUCTION

We aim to replace the traditional methods of charging electric vehicle by a more effective and cheap method. Currently, most of transport industry is burning natural gas and oil. The problem is, these methods are not cost effective. They are depleting the limited energy resources of the country plus they are polluting the environment too. So it will be a lot more beneficial if we design a system which will replace these methods by using renewable energy sources. The most convenient of all the methods is to make use of solar energy to power our transport industry. As Pakistan has a lot of potential for solar energy, so it is quite obvious that our newly designed system will be comparatively much cheaper and cost effective. Solar energy is cheap being used worldwide to accomplish various energy demands to some extent. It will, therefore, provide us with an efficient method to use solar energy for transportation. We have developed a charging system for electric vehicle. Using this method, we developed a prototype which met our requirements. Based on this prototype and our calculations, solar energy has a potential to replace the older means of energy production in transport industry. This project provides the complete feasibility of using solar energy for transportation.[1]

1.1 Motivation

Pakistan has a shortage of energy and most of our power is coming through the traditional source of energy, Major source of energy is using imported oil which is very expensive and causing a tremendous amount of pollution. One of the major consumers of power is our transportation industry which is using oil and natural gas for powering. These traditional sources are expensive and also depleting day by day. Solar energy is that energy that is clean and has a great potential to be used in transport industry.

1.2 Electric Vehicles over traditional oil powered vehicles.

Electric Vehicles are the new revolution in transportation industry. EV uses electrical power instead of thermal energy for propulsion, electric vehicle doesn't include only road based transportation mode rather it include rail based or electric aircrafts too. Electrical energy can be given directly from inside or from outside the body of electric vehicle. Electric vehicle has more efficiency than traditional IC engines vehicle and they have other benefit of pollution reduction and less noise pollution than traditional vehicle. Tradition vehicles uses oil or gas for producing thermal energy and this causes a lot of pollution and make our environment polluted with undesired amount of smoke. On the other hand electric vehicle doesn't produce any pollution because electrical energy doesn't produce thermal energy for their propulsion. World is changing its trend towards the electric vehicles and demolishing the traditional vehicles. Many countries has introduced policies to eliminate the traditional vehicles and promote the use of electric vehicles.

1.3 Powering electric vehicle

Electric vehicle can be given power in many ways. Two methods that are being used are on station power source or off station power source

1.3.1 On station power Source

For on station power source mostly batteries are used that will turn the chemical energy into electrical energy that will in turn used for propulsion of traction motors. These batteries mostly used are lithium ion batteries or lead acid batteries. Both type of batteries has pros and cons. In case of on station power source battery selection is very important and cost calculation is done while designing electric vehicle specification.

1.3.2 Off station Power Source

In case of off station power source power is provided to the traction motor from outside the body of electric vehicle mostly done in railways. Power is being provided through cables or beneath the tires that in turn being used by the traction motor. Off station power source electric vehicle doesn't have issues about the weight as no power source is being installed on the electric vehicles but it has limitation as it can be used only in that areas where and off station power source is provided and it has to be maintained on regular intervals.

1.4 Contribution

The goal of our project is to develop a prototype that is being uses an on station power source (Battery) and that source is charged by using solar energy. Main focus on project is basically provide a solution for transportation industry. Our project mainly focus on a solar powered train that carry a power source and can be charged using solar energy after specific intervals hence decreasing the cost of electric wire and constant maintenance . In this way this project will provide a solution that can be adapted readily and used against conventional powering of electric trains. For the areas that have rich potential of solar energy can use this solution and provide a much cheaper and safe mode of transportation.

2 CHAPTER 2: LITERATURE REVIEW

2.1 Background

Solar energy is as old as human kind and it is being used for ever since. Electric vehicles too are used in rail industry from a long time as electric traction motor can operate at lot more higher rpm than traditional IC engine. Using solar energy for electric vehicles is a new field and main focus of our project is also on utilizing this energy for transportation energy.

2.2 Energy sector in Pakistan

Pakistan is experiencing a major shortfall in energy sector as most of the energy is being produced through Hydel power that has been depleted and dams are not sufficient to provide that kind of energy hence to meet the energy need we are using thermal energy power by burning expensive oil and natural gas. Oil is being imported from other countries casing a major share of investment on that end while natural gas resource of Pakistan is depleting and according to survey natural gas reservoir will end after 24 years. One of the major sector in consuming power is transportation sector which are using 98% need from oil and 2% from natural gas. This cause a major portion of our GDP is being consumed in powering our transportation industry. While utilizing natural gas for transportation our domestic user get affected drastically increasing the load shedding of natural gas for domestic user.[2]

2.3 Environmental pollution

To solve the environmental problems that we are facing today we need long term actions on sustainable development environmental campaigns need to take collective step back and rethink everything. Because from 1751 to mid-2000, 337 billion tons of carbon has been released into environment due to ignition of fossil fuels, most of it happened since the mid 1970's.[3] The main cause of environmental destruction is transport it is responsible for 13% of total CO2 production in 2004. Global average surface temperature has increased almost 0.6˚C since 2001, few areas such as East Asia, Eastern North America, and Western temperature has been reduced rather than warmed in the past ten years. Environmental aerosols has prominent role in climate change.[4] [5]Aerosols have very small lifespan (days to weeks) in comparison to most greenhouse gases, they try to dense near their release sources and scattered in non-uniform manner

both in time and space.[1] This uneven distribution of aerosols, with the greenhouse effect, may cause differential net increase in temperature in some areas and net decrease in temperature in others. Sulfate aerosols come mainly from the oxidation of sulfur dioxide (SO2) produced from fossil fuel burning. Black carbon aerosols are released due to incomplete combustion of biomass, coal, and diesel derived sources. It also has optical properties due to which sulfate and black carbon affect environment and weather in different ways. Climate catastrophes are contributing to global warming because of greenhouse effect .increase in temperature is also disturbing the biological balance and leading to extinction of useful species and increasing the production of harmful insects of plants for which the warm environment is most suitable.[6] Other emissions like NOX and SOX cause mutations and many dangerous diseases .thinning of ozone layer is another consequence of these harmful gasses and it leads to skin cancer.[7]

2.4 Sustainable transportation

Transportation sector is one of the most neglected area in when we talk about the optimization of energy. According to survey almost one third of total energy is consumed by transportation and almost one fifth of total greenhouse pollution is caused by the use of fossil fuel in transportation [8]. In recent years some countries have developed some policies to decrease the use of fossil fuels burning vehicles and have converted the trend towards electrical vehicles. [8] countries like Denmark that have decrease the consumption of energy in each sector by 30 percent has failed to decrease the use of energy in transportation sector and has been increase by 50 percent and that us an alarming situation . Sustainable transport is the need of our present and future and should be used as traditional vehicles are constantly polluting the environment. according to a survey Lahore in Pakistan is one the most polluted city when it come to the air quality and most of these pollution comes from the transportation as mostly used fuels are gas or oil. Using solar energy in thermal form or in electrical energy that has been produced by PV cells can be used in Electric vehicle that can store that energy In batteries.[8]. Fossil fuel are not unlimited so even apart from the environmental issues due to limited resources we need to find an unlimited or greater source of energy and we know this for a fact that all the energy sources on earth is from the sun and it is main source. Targeting specifically transport sector is also important because in Pakistan efficiency of all heat engines is lower than electric power generation which cause more pollutants in the air.[9] So using solar energy in transportation can be economically beneficial as well as environmental issues gets a solution.[2]

2.4.1 Solar powered transportation

In Pakistan transport sector consume 48 percent of total oil petroleum. Due to increased energy crisis and environmental issues in 1970 the interest in solar energy sources. From environmental point of view solar vehicles are best because they offer zero % release of pollutants into air by converting light energy into electrical energy. So there are no greenhouse gas emissions with solar energy and the energy payback period is almost double which 1 to 2 years depends upon the quality of technology. Therefore, this technology is very beneficial since it solves two of the world's major issues of energy and environment, collectively. This is a major benefit of solar penal which make them the best alternative for fossil fuels. Fossil fuels, on the other hand, are all limited and not renewable and also harmful to environment, which is another issue of time. [10]

2.5 Advantages of Electric Vehicle

Many advantages of using electric vehicles are reduced CO2 emission and reduced noise pollution. Main challenge in the designing of electric vehicle are battery as battery life is in question due to its cost and weight.[8]

2.6 Kinds of EVs (Electric Vehicle)

There are three types of electric vehicles that are being manufactured in the world

Hybrid Electric vehicle (HEV)

Plug in Electric Vehicle (PHEVs)

Full Electric Vehicle (FEVs)

Figure 1 Types of EVs

Types of electric vehicles.

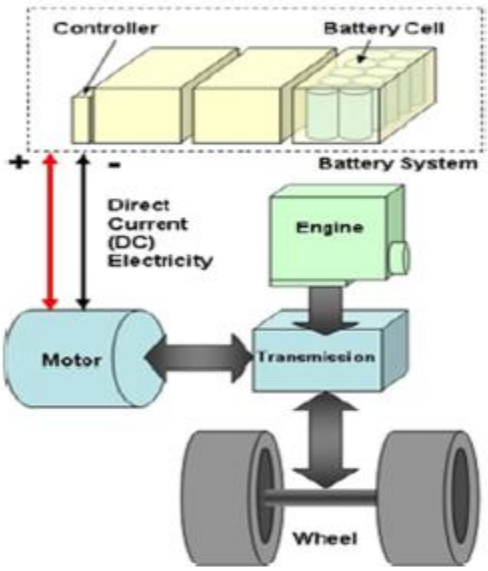
Vehicle type	Internal combustion engine	Battery charging
Hybrid electric vehicle	Yes	On-board (internal)
Plug-in electric vehicle	Yes	On-board (internal) and/or external charging
Full electric vehicle	No	External charging

[11]

2.6.1 Hybrid Electric Vehicle (HEV)

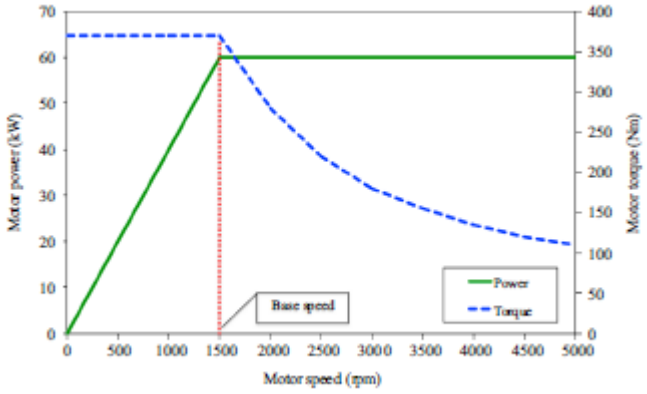
Hybrid electric vehicle uses two energies to propel the engine. Conventional IC engine power is combined with the electrical power of battery. These two power are then used and it gives us an increase in efficiency of vehicle and gives us a low carbon emission especially in the rush hours more power is derived from the electric motor. Charging of battery pack is done by using the generator power of the vehicle.

Figure 2 Hybrid Electric Vehicle



In full HEV vehicle an integrated motor generated system is installed which can be used to start the IC engine by acting as a generator and can be used as an motor to propel the tires by acting as a motor. At lower speed and higher torque electric motor is used but as speed increase the IC engine come in action and power will be delivered by the IC engine. Battery pack is kept at a constant state of charge by the on station charging, no outside charging is done in hybrid electric vehicles.[11]

Figure 3 Electric Vehicle performance

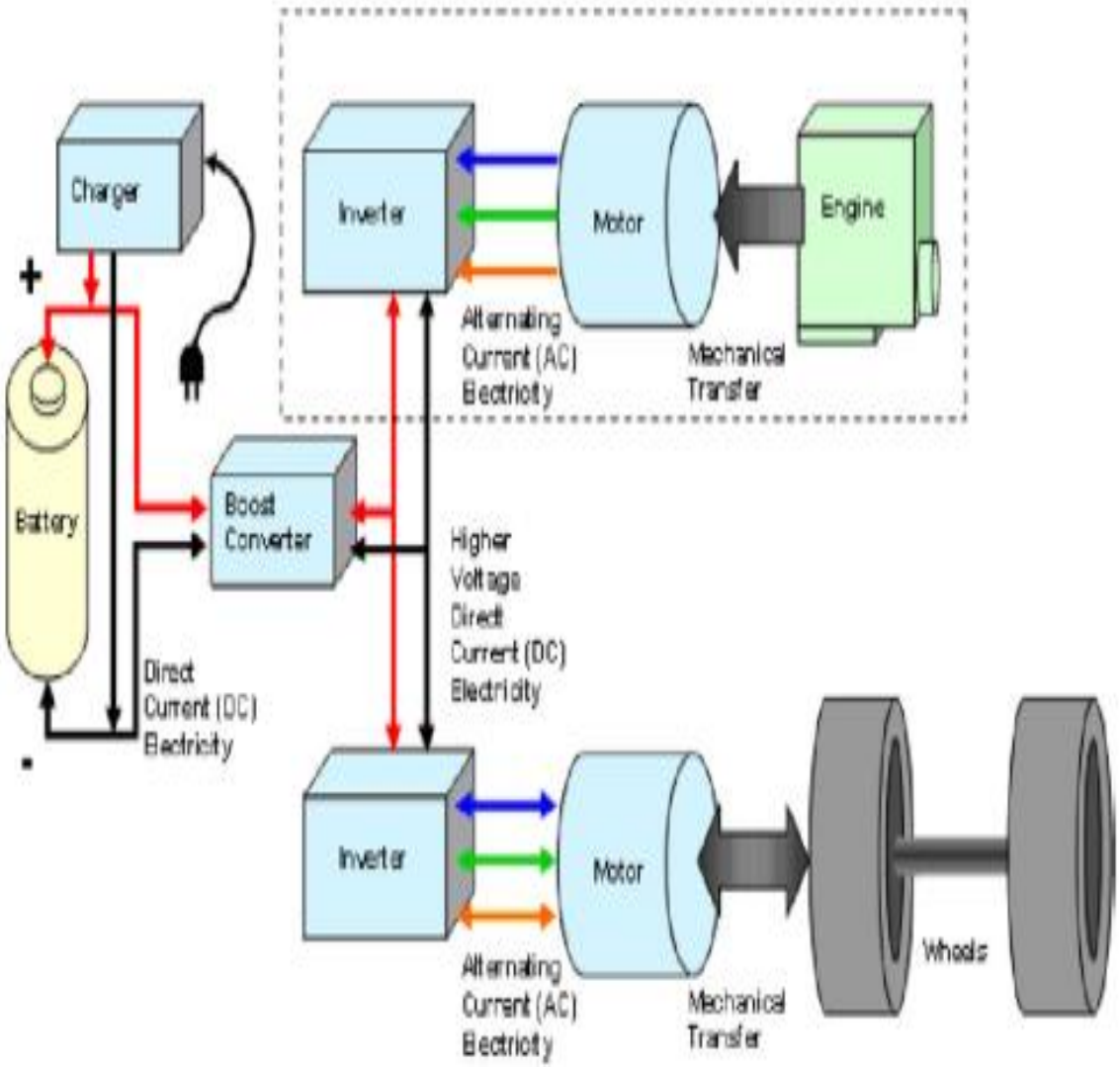


[11]

2.6.2 Plug in Hybrid electric vehicle

PHEV is a new technology which has a storage capacity for the electric power of at least 4kwh or it should at least cover 16 km electric mode, this type of vehicle can be charged from outside too. It has many advantage as it can work more on electric power hence decrease the using of fossil fuel in IC engine mode.in this type of mood charging is done from outside rather than on board charging like in hybrid electric vehicle. These can be charged at standard charging stations and studies show that co2 emission throughout their life cycle is much less as compared to the conventional IC engine. Regenerative braking system is also used to charge the batteries as an alternative.[11] Plug in hybrid electric vehicle will gives us a reduction in NOx by 25-55%, green house reduction in 35-65% and 40-80% in gasoline consumption.[4]

Figure 4 Plug in Hybrid Electric Vehicle



2.6.3 Complete Electric Vehicle

Complete electric vehicle uses an on board charge storage system that are batteries mostly to provide electrical energy to the electric motor or traction motor. These batteries are rechargeable. Sometime other system like flywheels can also be used for the production of electrical energy in complete electric vehicle. As compared to the hybrid and plug in hybrid electric vehicles these vehicles have a lot more reduction in harmful pollutants. As it only uses the electrical energy without using any IC engine power for the propulsion. There are many advantages of complete electric vehicle such as for lower speed it provide much more torque than a hybrid vehicle and give you a fast speed in much less time than any other vehicle in most advanced electric vehicles Li Ion batteries are used and range of these vehicle vary between 120-390 km and maximum speed of 200km/hour.

Figure 5 Complete Electric Vehicle

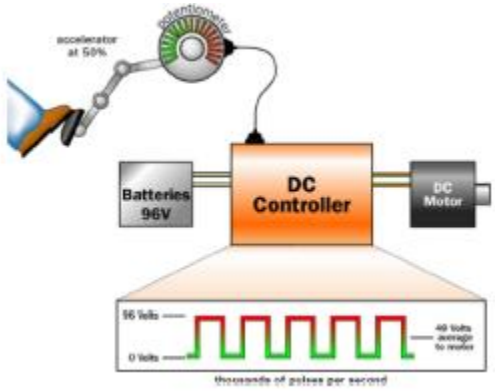
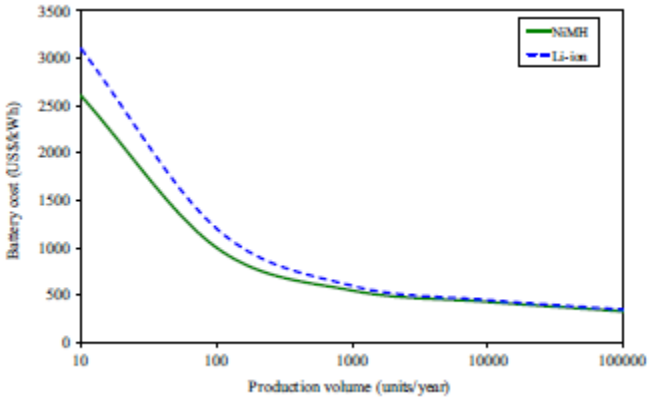


Figure 6 Mass production of batteries cost analysis



2.7 Energy policies and future prediction for Pakistan

For developing countries, sustainable energy is only solution for growth and economic development. Pakistan needs more energy which cost less and fill up energy deficit. Policies are being developed to fulfil development and generation of energy. As world is moving toward green energy Pakistan has also begin toward solar and wind energy. Policies are being made to cover deficit of more than 5000MW energy generation. New policies are being made to reduce standard oil and coal generation to green energy. Aim of studies is develop policies to implement green energy in Pakistan.[12] As we know green energy has high potential and low runny cost.[12]

Figure 7 Fuel consumption in Pakistan

Fuels consumption (MTOE) and Annual compound growth rate (percent) in base year (2011-12).

	Fuels										
	Oil		Natural Gas		Electricity		LPG		Coal		Overall Sector ACGR
Sectors	Cons.	ACGR	Cons.	ACGR	Cons.	ACGR	Cons.	ACGR	Cons.	ACGR	
Domestic	0.082	−5.6	6.129	7.1	2.898	1.3	0.251	−10.5			4.2
Industry	1.423	−2.6	7.778	−1.3	1.776	0.7			4.057	−0.4	−1
Agriculture	0.024	−24.9			0.696	0.9					−1.3
Commercial			0.927	4.8	0.469	1.4	0.190	−1.7			2.9
Others	0.310	−1.9			0.413	1.3	0.040	25.3			0.6
TPG	7.410	2.4	6.733	−4.9					0.0468	−8.6	−1.5
Fertilizers			3.974	1.00							1
Transport	9.78	3.0	2.785	16.1	0.000081	−39.1					

Legend: Cons.: Consumption, ACGR: Annual compound growth rate.

[12]

Oil consumption is being increased in Pakistan because of lack of green energy. To complete up the deficit energy is being generated from fossil fuel. Fossil fuel is expensive and so cost of energy generation increases. Added to the cost, fossil fuel are major cause of global worming as shown by report in Lahore city i.e. smog.

Policies are being developed by previous and current government to control global warming by moving toward more green energies like solar energy, wind energy and water energy. Temperature of cities is controlled by planting tree thus increasing solar efficiencies. LEAP modelling is done to predict future reserve of fossil fuel and nuclear energy. By results of modelling it is clear that these reserves are depleting and up to 2030 these reserve will be lower than 131.8 MOTE. Budget are being assigned to these policies which greater than 1000MUSD.

3 RESEARCH METHODOLOGY

In this chapter I will discuss about our research approach in finding a way for charging a prototype model by solar energy and discussing the aspect of the research about feasibility of solar powered train.

3.1 Experiment planning

The main purpose of this research is to conclude the feasibility of solar powered trains in the world. Solar powered trains that have on board storage capacity like batteries. Experiments that are done here is to calculate the charging time and feasibility of charging time with respect to an actual prototype. First of all a 12 v battery is being charged using solar energy and its results are than compared with charging time of this battery with WAPDA power. In second step an actual model of electric bus having a battery bank of 48 volt is charged with solar energy and then with WAPDA power, charging time of both energies are calculated giving us a result and feasibility of using that energy on commercial scale.

3.2 Battery Charging (12 Volts)

For this mode of experiment a 12 volt battery is purchased having a capacity of 110 AH. Battery used here is of VOLTA Company and of type lead acid battery. As lead acid battery is readily available in Pakistan so this battery is used for the testing.

First of all battery is completely drained and charge state of the battery is at 40 percent. As energy density of lead acid battery is less so when state of charge remain 40 percent we switch off the batteries and considered as completely drained. If we drain more energy from that state we will eventually decrease the life of battery.

Figure 8 Battery Used in experimentation

3.2.1 Solar Charging (12 Volt)

For Solar charging a charger is being developed in collaboration with LUMS. Solar charger used microcontroller MPPT for the charging of 12 v battery. Benefit of using MPPT controller is that maximum energy is derived from the solar panel. Solar panel that is used in this case of charging is of 325 watt and having a maximum voltage of 40 volt and current rating of 9 A

Figure 9 Solar Panel Specification

MECHANICAL PARAMETERS

Cell (mm)	Poly 156.75x156.75
Weight (kg)	23 (approx)
Dimensions (L×W×H) (mm)	1960×991×40
Cable Cross Section Size (mm^2)	4
No. of Cells and Connections	72 (6×12)
Junction Box	IP67, 3 diodes
Connector	MC4 Compatible
Packaging Configuration	27 Per Pallet

WORKING CONDITIONS

Maximum System Voltage	DC 1000V (IEC)
Operating Temperature	-40℃~85℃
Maximum Series Fuse	15A
Maximum Static Load, Front (e.g., snow and wind) Maximum Static Load, Back (e.g., wind)	5400Pa (112 lb/ft²) 2400Pa (50 lb/ft²)
NOCT	45±2℃
Application Class	Class A

Figure 10 Electrical Properties of Solar Panel

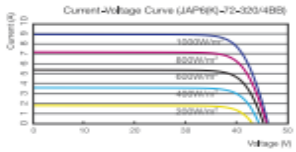
ELECTRICAL PARAMETERS

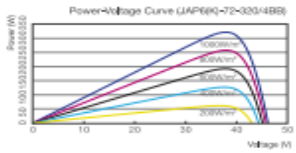
TYPE	JAP6(K)-72-310/4BB	JAP6(K)-72-315/4BB	JAP6(K)-72-320/4BB	JAP6(K)-72-325/4BB	JAP6(K)-72-330/4BB
Rated Maximum Power at STC (W)	310	315	320	325	330
Open Circuit Voltage (Voc/V)	45.56	45.85	46.12	46.38	46.40
Maximum Power Voltage (Vmp/V)	36.89	37.09	37.28	37.39	37.65
Short Circuit Current (Isc/A)	8.92	9.01	9.09	9.17	9.28
Maximum Power Current (Imp/A)	8.40	8.49	8.58	8.69	8.77
Module Efficiency [%]	15.96	16.22	16.48	16.73	16.99
Power Tolerance (W)	-0~+5W				
Temperature Coefficient of Isc (αIsc)	+0.058%/℃				
Temperature Coefficient of Voc (βVoc)	-0.330%/℃				
Temperature Coefficient of Pmax (γPmp)	-0.410%/℃				
STC	Irradiance 1000W/m^2, Cell Temperature 25℃, Air Mass 1.5				

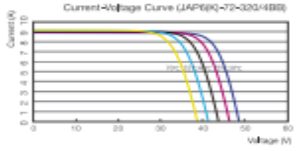
NOCT

TYPE	JAP6(K)-72-310/4BB	JAP6(K)-72-315/4BB	JAP6(K)-72-320/4BB	JAP6(K)-72-325/4BB	JAP6(K)-72-330/4BB
Max Power (Pmax) [W]	225.06	228.69	232.32	235.95	239.58
Open Circuit Voltage (Voc) [V]	41.63	41.84	42.04	42.24	42.41
Max Power Voltage (Vmp) [V]	33.87	34.00	34.19	34.37	34.58
Short Circuit Current (Isc) [A]	7.03	7.08	7.14	7.20	7.25
Max Power Current (Imp) [A]	6.65	6.73	6.80	6.87	6.93
Condition	Under Normal Operating Cell Temperature, Irradiance of 800 W/m^2, spectrum AM 1.5, ambient temperature 20℃, wind speed 1 m/s				

I-V CURVE

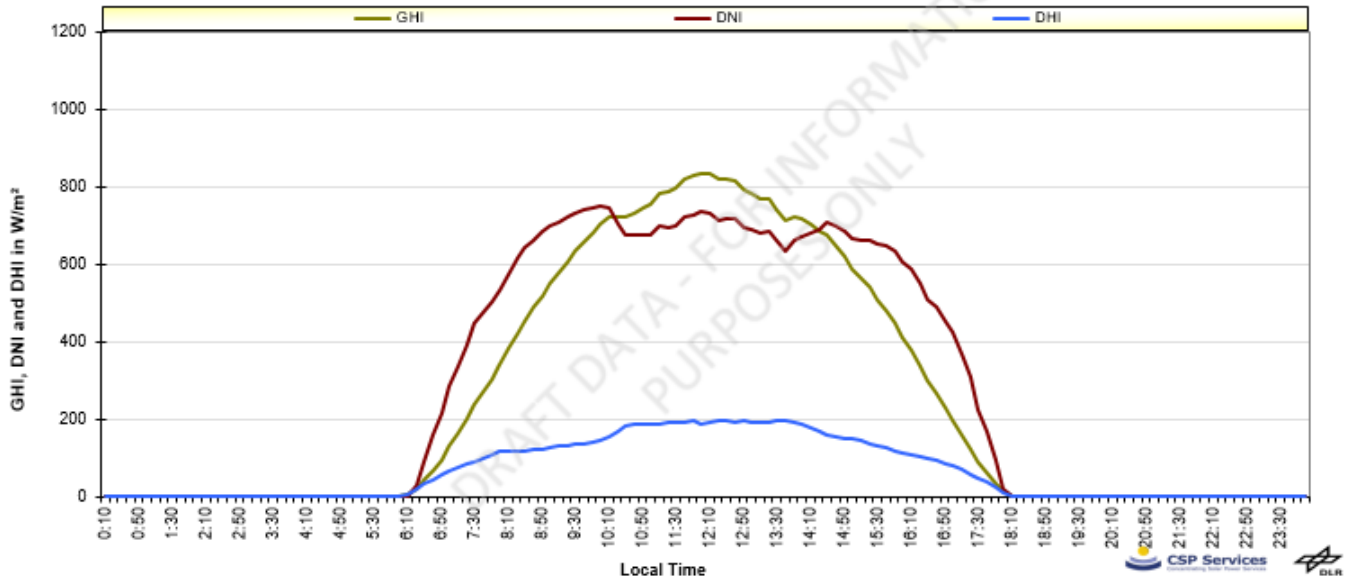






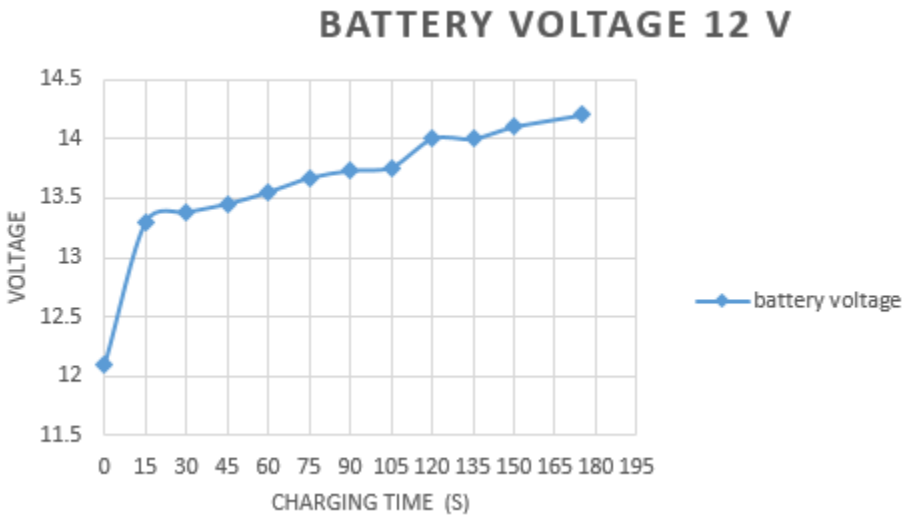
Solar panels used are from company named Canadian Solar. Solar charging is started on bright sunny day when solar intensity is being calculated.

Figure 11 Solar Intensity



Battery is being fully charged with the solar energy and total time is roughly 4 hour

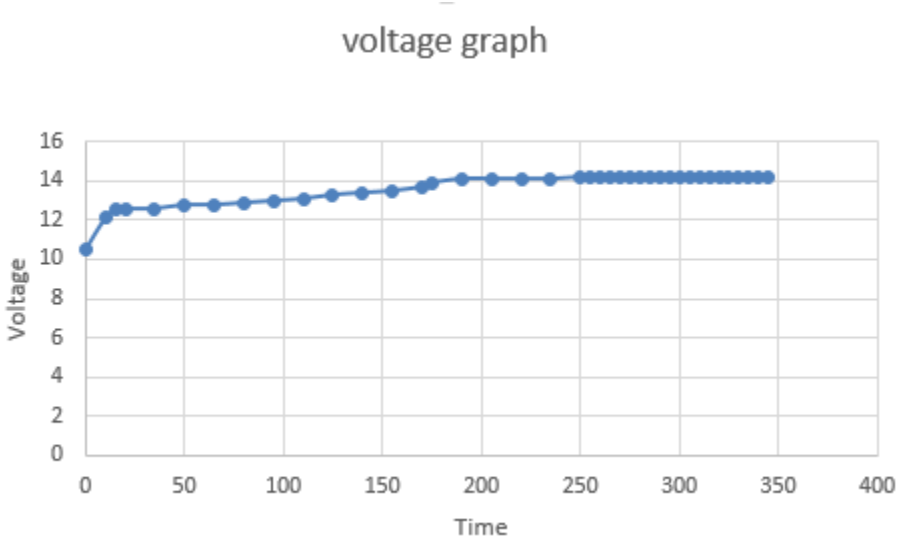
Figure 12 Solar Charging of 12 V Battery



3.2.2 WAPDA charging of 12 V

When battery is fully discharged it is than charged by using the wapda power and result has been calculated. For wapda charging a standard UPS is used for company named Hyundai of power 750 watts. No load is applied so all the wapda energy is going towards the battery. Standard wapda charging if of 220 volts and that Alternating Current is than converted into Direct Current and used to charge the battery.

Figure 13 WAPDA Charging Graph (12V)



Throughout the time there was not power loss and voltage of wapda remains constant.

3.3 Electric Vehicle Charging

Electrical vehicle prototype is manufactured by NUST SMME. This vehicle is called electric bus having a seating capacity of 10 person. Battery bank installed on the electric bus is of 48 volt. Batteries that are used are of lead acid type and a brushless dc motor of 10KWatts is used for the propulsion of the bus. Currently bus is operating in NUST and used as a shuttle service for the students of the university. An on station solar panels system is also installed on the roof of the bus but that is not enough to charge the batteries in enough time. But it helps the battery bank to gain some potential and prevent the batteries from deep discharge. Electric vehicle is designed and fabricated locally and it has more potential to be commercialized. In this research our main focus is first to optimize the efficiency of electric vehicle and second we have to give a

feasibility of using that system into rail system. As rail system require much less energy than the road driven vehicles.

Figure 14 Electric Vehicle (Front)

Figure 15 Electric Vehicle (side)

Figure 16 Electric Vehicle (Charging)

Figure 17 Electric Vehicle (Battery Bank)

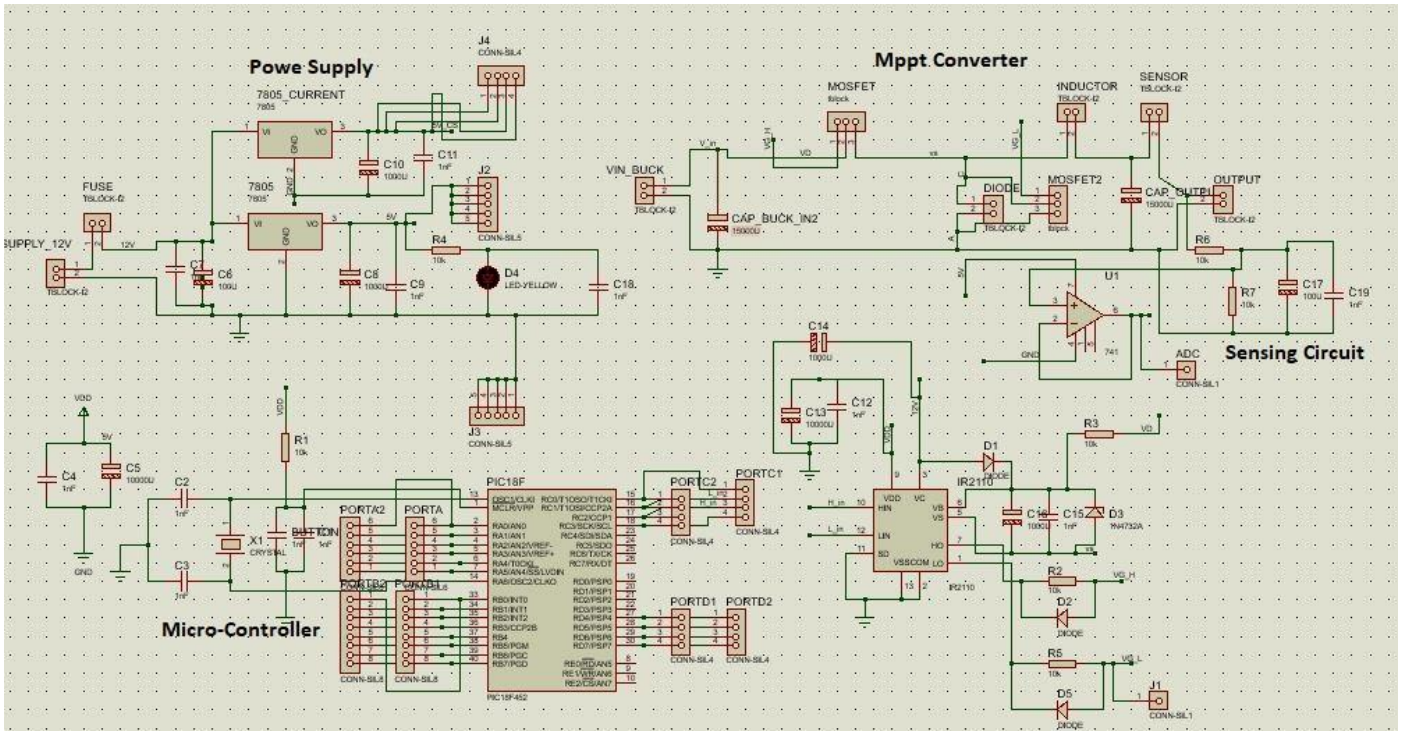
3.3.1 Solar charging of Electric Vehicle

For solar charging of electric vehicle 4 solar panels are used each of 325 watt. For charging purpose 2 solar panels are connected in series and other two in series and then two of these system is connected in parallel. By combining these four panels we get a total 80 volt and 18 A charging station ideally. For charging purpose a charger is being developed in collaboration with LUMS.

3.3.1.1 Solar charger

Solar charger that is being developed is made through using MPPT converters. Charger input is 80 volt solar energy and that energy is fed to battery bank at the voltage of 48 volt. Maximum voltage that is achieved is 60V

Figure 18 Solar Charger Design



3.3.1.2 Solar charging of EV

Solar charging is done on a bright sunny day started from the morning. Solar intensity on that day is recorded and its graph is given below

Figure 19 Solar intensity(48V)

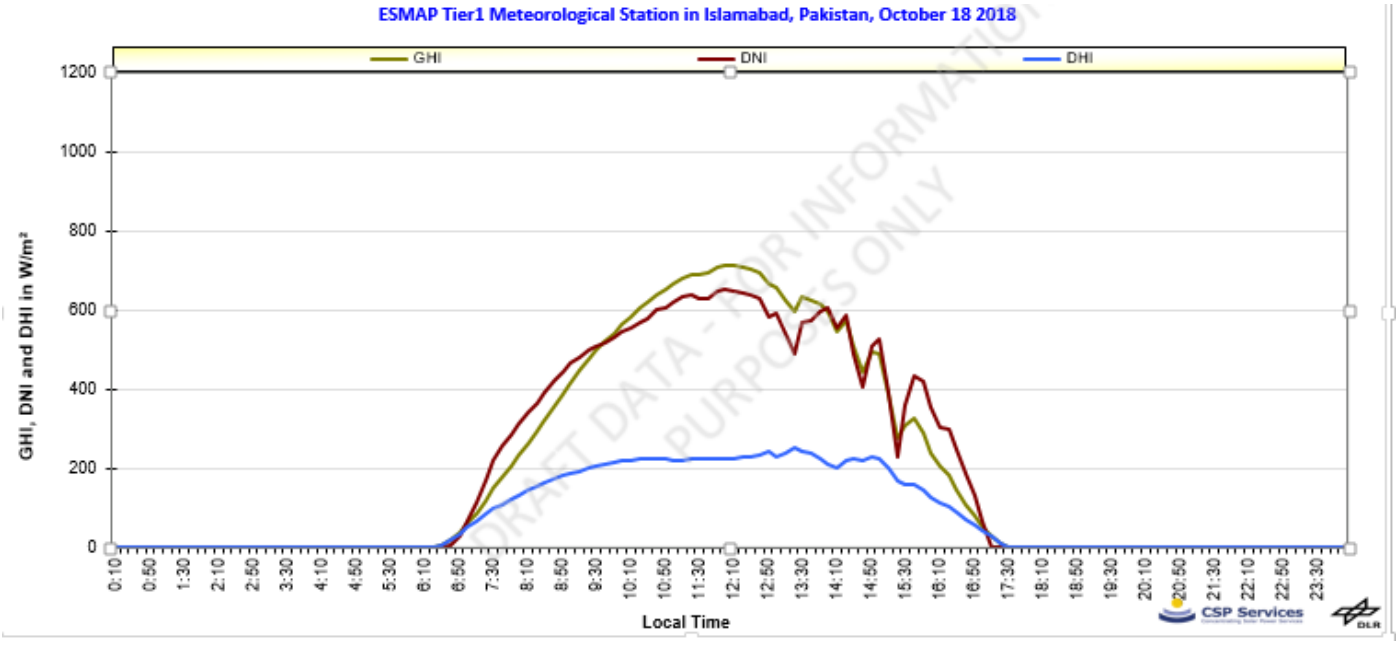
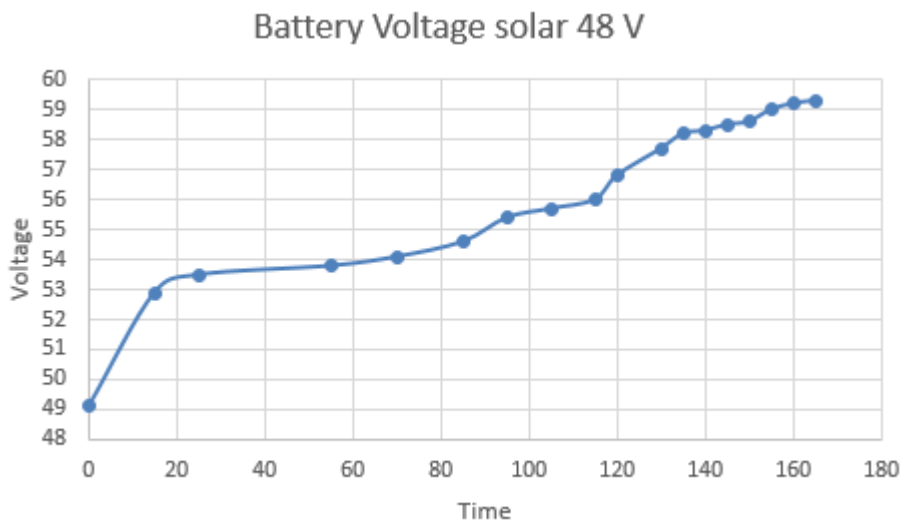


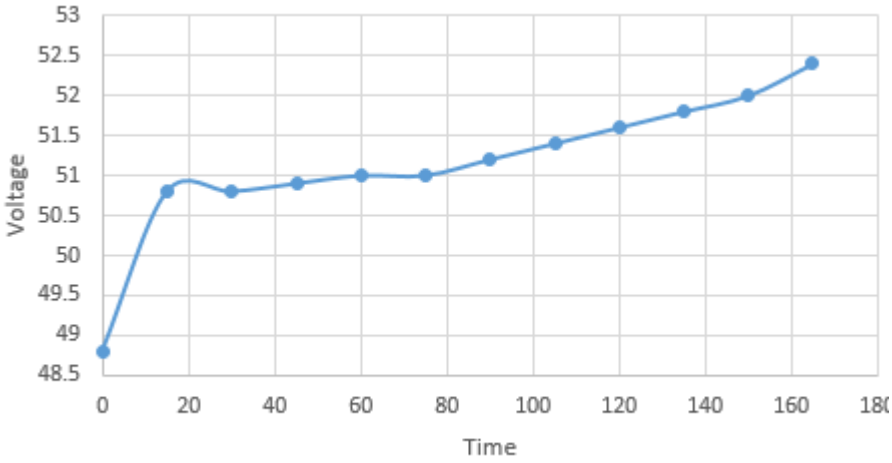
Figure 20 EV charging voltage



3.3.2 WAPDA Charging of EV

For WAPDA charging we use the existing charger used for the electric vehicle charging. We have charged our battery from wapda charging and this will gives us a comparison of charging the electric vehicle with solar energy and gives us a preview of using this energy for solar powered train.

Figure 21 WAPDA charging of EV



This charging is for only 180 minutes and charging done by solar energy is also for 180 hour and we have determined the potential of solar powered transportation.

Figure 22 EV charging

4 RESULTS AND DISCUSSIONS

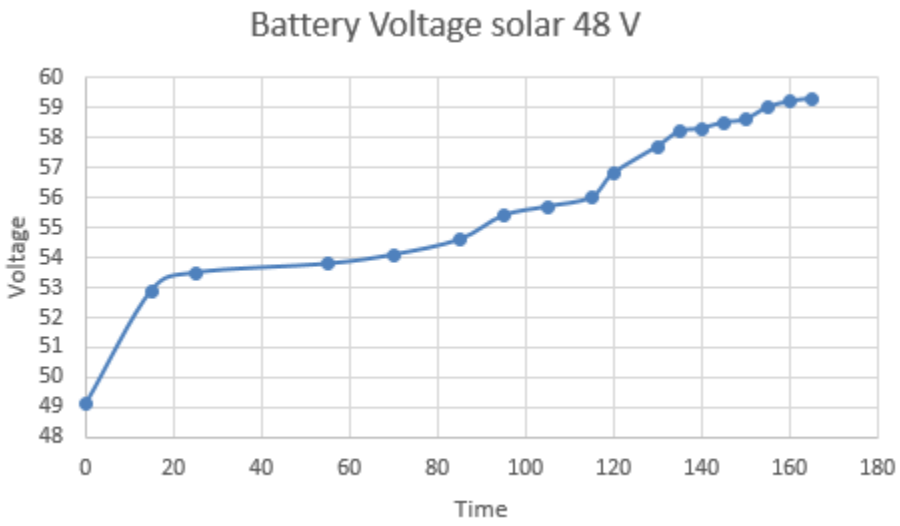
In this section all results will be given and discussed

4.1 Electric Vehicle solar charging

Table 1 EV Solar charging

Time	Battery Voltage
0	49.1
15	52.9
25	53.5
55	53.8
70	54.1
85	54.6
95	55.4
105	55.7
115	56
120	56.8
130	57.7
135	58.2
140	58.3
145	58.5
150	58.6
155	59
160	59.2
165	59.3

Figure 23 EV Solar Charging



Above graph given is the solar charging done through solar charger. In this case solar charging speed is much greater

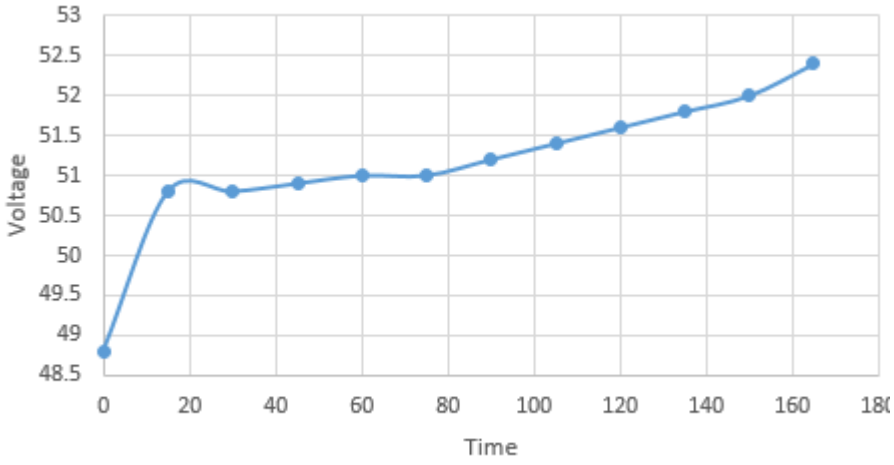
4.2 EV WAPDA Charging

Wapda charging is done using normal charger here are the data that is been collected while wapda charging is done.

Table 2 WAPDA Charging

Time	battery voltage (V) wapda
0	48.8
15	50.8
30	50.8
45	50.9
60	51
75	51
90	51.2
105	51.4
120	51.6
135	51.8
150	52
165	52.4
180	52.6
195	52.8
210	53
225	53.2
240	53.5
255	53.8
270	53.9
285	54.2
300	54.6

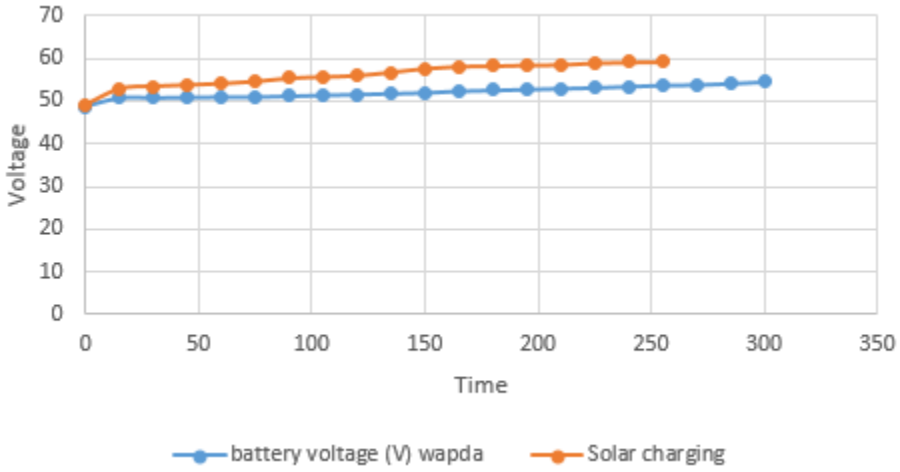
Figure 24 WAPDA Charging of EV



4.3 Comparison between Solar and WAPDA Charging

Comparison between two charging are given below:

Figure 25 Comparison



As we see from our experiment that solar charging is much faster than the existing WAPDA charging and we can charge our batteries in much less time using solar energy. There are other benefits of using solar energy, first one is that ripple voltage is not present in solar energy charging case as when AC current is converted into the DC current , it has some ripple voltages but in this case DC current is being used to charge the batteries.

In comparison of both we can say that solar energy charging has much more benefits than WAPDA charging and using solar energy is the new era in transportation

5 CONCLUSION

We have concluded in our discussion that solar powered transportation is the new future of transportation. Increasing pollution is an alarming situation and it can be reduced by using clean energy and implementing green technologies in the field of transportation has a very high potential. Greenhouse c=gases can be reduced easily by using solar energy powered electric vehicles and buses. Solar charging done on 12V battery shows us that charging time is almost remains the same as of WAPDA charging so it means that we can use solar energy for charging that batteries in our home. In next experiment I have concluded that solar charging is very feasible and economical as compared to the WAPDA charging and this charging will increase the life of the batteries because of having no ripples voltage. Results based on these experiments conclude that in Pakistan we can launch a train service that can be operated using solar energy and this train can revolutionize the transport in Pakistan, especially in the areas where there is no development this project can give them a cheaper mean of transportation.

6 FUTURE RECOMMENDATION

For future research a train prototype should be made in order to conclude the actual response of charging on a train. Because frictional values experienced by the train is much different than the bus that has been driven in the bus. I would also like to study the effect of temperature on charging as I observe that when temperature get too much high the power output becomes very less so some process should be derived to increase the efficiencies of panels. Effect of reflected light on solar panel can also be studies in future to increase the energy from solar panels.

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