Fundamentals of Electric Vehicles
Technology and Economics
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Lecture 72
Bulk Chargers, Swap Stations - Part 2

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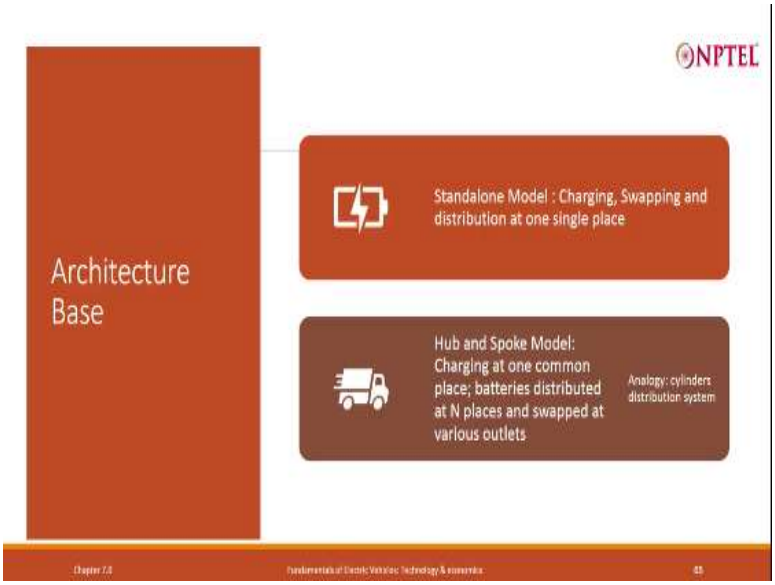

Now whenever we are talking about swapping there are two different standards or not standards, but two different types of architecture that one may follow. One is the standalone model where the charging swapping and the distribution happens at one single place. So, you imagine there is a swap station you go there he has that rack, he has kept the dispensing unit there and he also charges this at the same place.

Another model which is a hub and spoke model where assume that we have kind of a godown where the operator is charging all those batteries and in the morning somebody comes as a logistics driver or he has a van he takes those batteries and circulates it to all may be kirana shops or departmental stores or everywhere any hook and corner of the city where there would be number of people who would be coming to those stations to pick up those batteries.

So those are the stations where only swaps batteries are kept so interchanging station, but there is no charging that is happening there because he may not have a space, he may not have the electricity connection, he may not have the Ethernet connection and etcetera, etcetera largely a model that we follow for cylinders delivery system so cylinders are also delivered like that.

So not that all distribution centers for cylinders would have the cylinder filling station as well. So that is the model that we follow for hub and spoke model.

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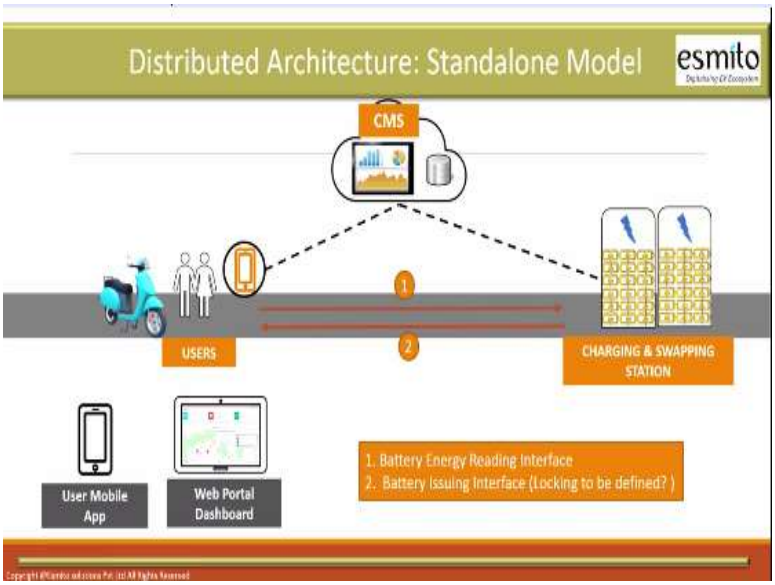

Now if we talk about distributed architecture it looks quite simple we say that it is a standalone model where everything is happening, but architecturally wise what is happening is there is a user who actually comes to a swap station, swap charging station and exchanges that battery. Gives the discharge battery ask for a charged battery back and goes away, but while he does that a lot of transaction is happening between that.

This guy should understand it is my battery or somebody's elses battery. He should also understand that how did he use this battery. I gave him the battery at such and such health of the battery, but when he gave it back what was the health and the status not only health how much energy that he has utilized. So, all that information he has to capture in that quick transaction that he does that he is giving you the battery and taking the discharged battery.

So in that quick interaction there has to be a system that tells that everything is fine and what is the usage, what is the bill and how he has to charge, unlike. So that is the difference between when we talk about cylinder system wherein cylinder is whatever level though they give 14.5 kg every cylinder that is a standard that they have formulated. So it is not that you would be utilizing less or you will be given more energy and all that.

So the fuel in that package remain same, but for us while we issue the battery it could be different capacity for two different users while we take the battery also you may use different

capacity he may use different capacity, so the utilization could also be different. So, when the utilizations are different we need to capture that what is the utilization that has happened and accordingly I need to bill him.

So that is what actually happens and the two interfaces that we define is battery energy reading interface and battery issuing interface which is nothing, but an interface between charger and the battery either that is what we would define or an interface if I am using an app to read the battery, so this is an app to battery interface or charger to battery interface. So this basically depends upon I am talking about an automated system or a system wherein I am using only a simple charger to charge the battery.

So if there is an intelligence in the charger it will read all that data and say that yeah I took the battery at this rate and I am dispensing it at this energy level and this is what I have to charge the payment and the payment comes on the top on the display board and you charge the bill he pays it there and then goes or else he uses his app. In the app you scan it and you get the notification that hey this is the bill I have to pay you pay the bill and you go. So both the interfaces could be there and all the interfaces would get recorded in your web portal or your server.

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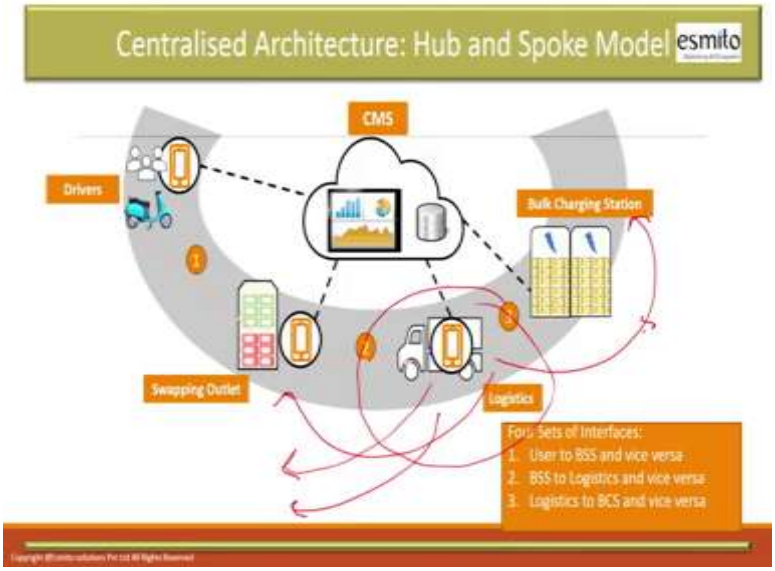

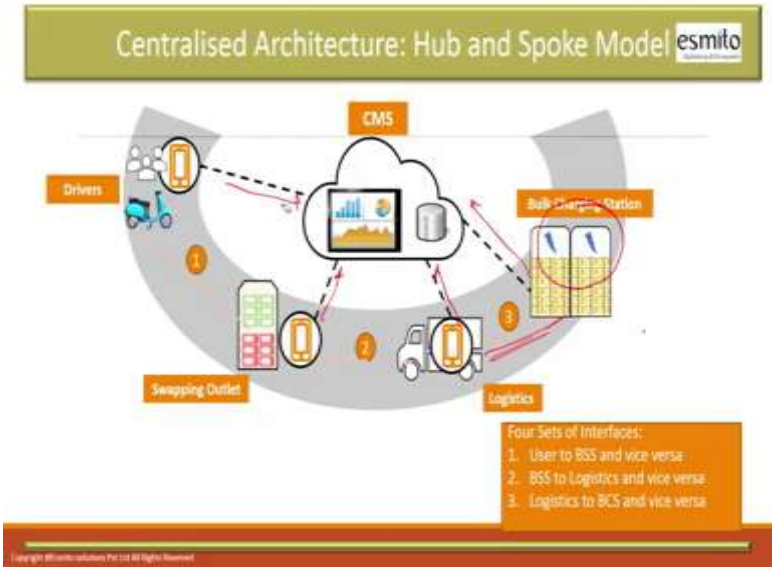

Second system which we call it as centralized architecture wherein the batteries are charged at one station and then get distributed to different levels. Now here what comes into picture is the logistics slag. So apart from that actually everything else is same. In the logistic slag, what is happening is that he is going this fellow is going to the bulk charging stations, collect those batteries and then start to drop in one swap station, second swap station, third swap stations and everywhere else he is distributing.

And what we need to do is that whatever distribution is happening we keep on controlling that distribution I mean you have all the records that at any given point in time what are the batteries that are there. So, your battery as an operator you need to track every moment. So every minute I should know that out of my one lakh batteries these many thousands of batteries are there in the swap stations.

These many batteries are there in the vehicles, these are there in the charging station, these are there in the maintenance center and these are there where some fault has happened and I need to take them out of the system. So at every given point in time since I as an operator own the asset and that is my business to track the asset because that is the business I need to make.

If I lose one asset also I am losing the business of the day or a month. So that is where you need to track all that information and that is how all those transactions need to be captured in the CMS. So 4 set of interfaces that we need to understand here; one the user to the base swap station, second base swap station to logistics and third logistics and vice-versa fourth logistics to BCS sorry fourth which is not specified here is actually all these interfaces to the cloud.

Now all the interfaces that happened to the cloud they could be either 2G, 3G we cannot have Ethernet, Ethernet can happen only here. The only interface that can happen on Ethernet is here but rest of them have to be the wireless interfaces.

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So coming to the swap standards like we talked about the public standards as swap standards also though they are no real standards that are existing globally none that has been standardized, but they are in draft stage I would say. So in the draft stage there are two standards one is IEC 61851 and second is 62840. Both these standards actually specify how to swap the battery with the swap station.

So they all talk about the battery as one actor swap station has another actor logistics come in one of these standards which is actually in 62840 and not being talked about 61851 and they also talk about how do we lay out the swap stations specifically this is talked about in 62840. When we talk about 61851 it just gives the basic definition that irrespective of the chemistry of the battery, the state of charge of the battery, state of health of the battery how to have, how to make the swap happened.

And how to make it risk free and safe, so all those protection mechanisms are specified and they also specified three levels of BSS that is fully automated, semi-automated and manual whereas when we talk about 62840 it talks about all different other aspects also. So what should be lane system, what should be the layout of the swap station?

So, if the bus is coming it should be coming from this direction and go out from this direction and that should happen and something like if it is a side swap or bottom swap or top swap how these things should be handled. So they layout very detailed mechanical system, very detailed handling system they also specify how the user should be actually interacting with the battery. So it is a very, very detailed system.

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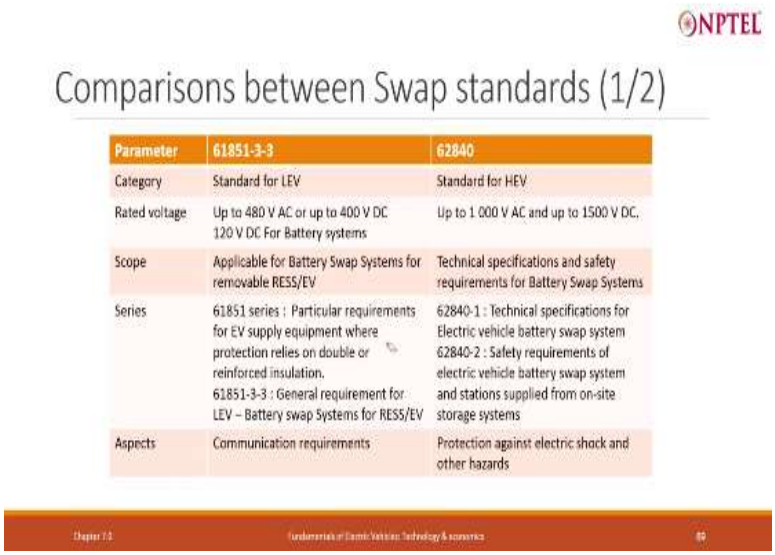

The difference between the two is 61851#3 is specified for LEV applications whereas 62840 is actually for HEV application so that is the most important difference between these standards wherein the voltages they cater to up to 120 volt DC whereas since these are HEV standards 62840 handles 1500 volt up to 1500 DC systems and if we talk about 61851 there are general communication requirements.

There are general protection requirement so on and so forth which are also there in 62840 apart from other layout etcetera. Not going much into details of all this, but yes what is happening between the standard the latest update is probably 61851#3 is getting scrapped and getting merged into 62840 or vice versa would happen. Why because ICE as a committee felt that there should be only one standard catering to the swapping.

And should not be categorized with LEV, MEV or HEV and everything should be taken up as a very holistic approach and specified as that if it is safety, for safety for LEV it should be this, for MEV it should be this and HEV should be this so that anyone and everyone who is looking at swap as a business or as an operation or as a technology then these are the things that should be taken care of and how to migrate from one system to another.

So whole of it is getting now merged though their standard is still to be out and at BIS also there is a standard committee that has just been formed with the mandate that we should have our own Indian swap standard because around the globe there are not much people or not much use cases for standards that emerge for swapping. Why is that because standards wherever it has been formed is fortunately, unfortunately you decide.

But yeah it has been through the developed countries and developing countries actually have been adopting those standards only which have been framed by developed countries. In the developed countries mostly which ever country we pick up where EVs would have happened and mostly like Scandinavian countries and other countries they do not have two wheelers and three wheelers.

In our country we have majority of two wheelers and three wheelers and even our delivery, logistics and all those used cases for commercial applications as well is being done more and more with two wheelers and three wheelers. Now if we talk about EVs as an adoption for all these services we also know that is EVs is not going to happen without swap why if it is commercial application people are not going to wait for charging their vehicle in the mid of their business.

And if it is a fleet operator let us say they are operating through three wheelers or cars if a car is taking 5 hours they are losing the 5 hours money. So obviously there would not be any shift from I to EVs for I to EVs in commercial application to make a sense for the EVs in that kind of a business swapping has to be there and you would say then why swapping, why not have long range vehicles.

The long range vehicles the problem is you need longer batteries also, longer batteries means high capacity batteries. So if we are talking about high capacity batteries that will result in problem of cost. So they will come out to be very costly and no one would be able to afford that. In whatever category we are talking about we cannot afford in general a bike of 3 lakhs, 4 lakhs, 5 lakhs for a delivery application because that guy cannot afford it.

So, if we have to talk about commercial business and the affordability end result of whatever technology we are talking about they have to make sense of it and that is where swapping has to be there and since we are not seeing that any developed countries or such standards would be there in place very soon that is where India thought that yes we need to do it and since there is no standard existing frame our own standards.

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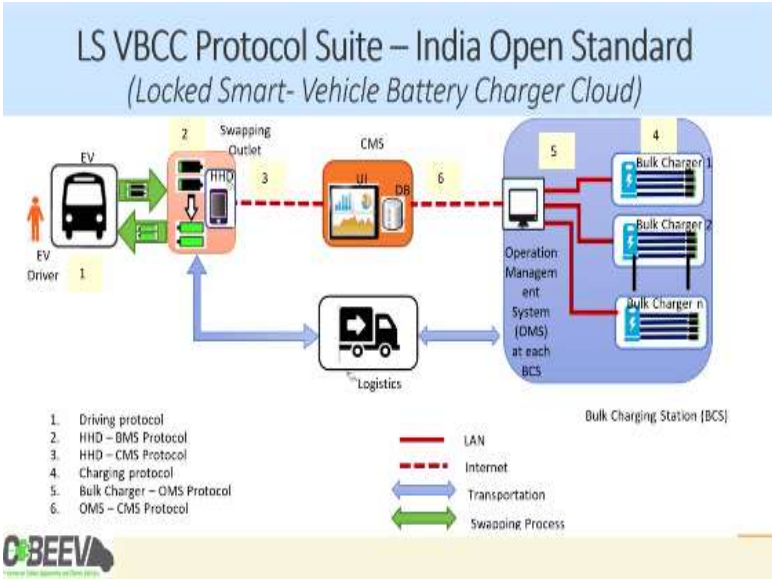

One of the standards LS VBCC that got formulated I would not say it is a standard by BIS there is a standard by open consortium which a center started to lead about 3 years back and we formulated that standard it is called as locked smart vehicle battery charger cloud protocol which we formulated with about a set of 35 companies. So there was a consortium which met and kind of started to define that what should be the interface.

What should be the message between EV and swap station or you say HHD which is a handled device nothing, but your mobile phone. What should be an interface and definition that you need to have between logistics, between CMS and the bulk charging station keeping on view one interoperability has to happen that you can have batteries from supplier A, B, C, D.

So what do they need to have as a communication protocol that gets mapped or working with the bulk charging station from again the OEM or the charging manufacturer A, B, C, D whoever. So there has be a linkage between that so that is specified. Second the safety and protections that have to be inbuilt and taken care of that what all different capacities should be there.

What should be the dimension of the battery, what should be the minimum performance? So what is also specified not in the protocol but in the overall standard is the minimum performance guarantees that you need to have. So since we know that chemistries are evolving. So we say that one of the limitations of the standard is that if we specify everything today how would we go to a next jump to the technology would we write another standard?

No, so what we thought was specify a minimum performance guarantee that in this size of the battery you are going to give me minimum of let us say 2 kilowatt hour energy you can provide better it is better, but minimum of this is what you have to guarantee you are going to provide. What else is required from a battery point of view is how many number of times I can swap that battery.

I can swap that battery 500 times or 1,000 times or 2000 times or 100 times only. So, this minimum warranty or performance is what the OEM has to guarantee me. So there are minimum performance parameters that are specified and good interfaces that would be there. So what kind of connector you should have and if your physical connector is defined what is the communication over which you should be communicating.

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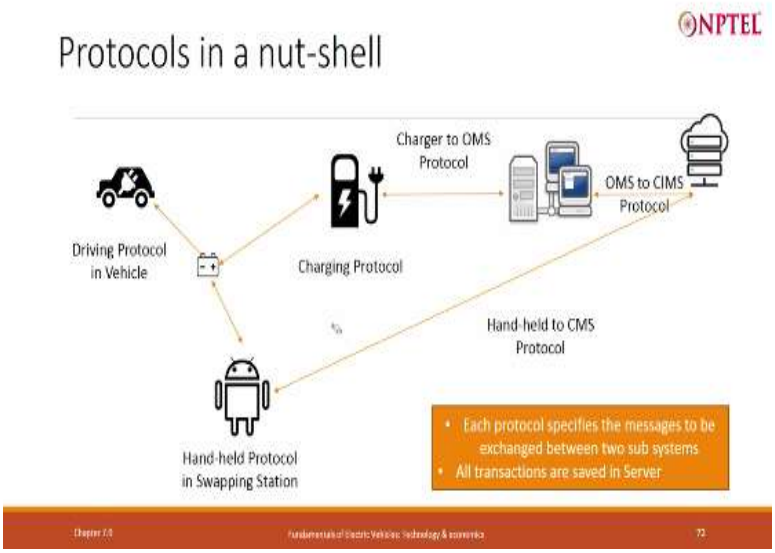

Overall, if we talk about protocol in a nutshell we have our battery as our first actor, EV as second and there is a driving protocol that is specified between the EV and the battery because that is where authentication has to happen between the battery and the electric vehicle and authentication would only happen if we have actually standardize the protocol, but given a lot of confidentiality and inscription that happens between these two devices to say that yes they are able to authenticate each other.

And there is always a newer key that is generated as far as that particular vehicle is concerned because we want why is that because we are talking about locked smart battery. It needs to get locked with that particular vehicle. So this particular vehicle one particular key has to be

there which is very unique in nature and cannot be duplicated so that is one standard we call it as driving protocol in vehicle which also specifies not only the authentication key.

But also tells that what are the data I should capture during drive and in what format I should store that data. Second the interface that we have between the two actors as battery and the user which is the handheld device. So, how should I communicate that, how should I tell as a battery to this mobile user that this is my current state of charge, this is my current state of health and this is how I have been utilized.

So that and then with the charger, so if we see for a battery the battery has 3 interfaces; one with the user another with the charger third with the vehicle and whole of this is actually specified in the protocol and finally how would the charger get all the data from the battery and push it on to the cloud. So whole of it is actually specified with the great details on the message, message structures and all that information.

And finally to the user what all information as a combined information you should actually relate to that and remember that all these complexities the users or we as public or uses of the technology we do not want to know that what are the complexities, what is happening behind that, so how do we represent it in a very, very simplistic terms is also basically some definition that is given here that is all actually I wanted to cover today both on public chargers and swap stations; any doubts here?

Any questions on swapping could be around protocol could be around standardization, could be around chargers technical or business side anything that you have in mind you are curious to know please do ask.

Student: When we are talking about locked smart battery, casing is finally a mechanical who can (())(19:57) what cost most is the cell, cell can be recovered and it can be used, one can have a low cost (())(20:04).

Professor: What will we do with?

Student: With that is an idea.

Professor: with cells?

Student: Yes, not only cells, if any theft pattern it generally not used as it is, cell either will cut in pieces or parts recover and then sell it, same thing can happen.

Professor: True, so what we are trying to address is that not everyone thinks about stealing the battery right if everyone knows that we have been trapped so there it is kind of I cannot really give a good analogy when we say that yeah you have CCTV cameras. Now CCTV camera do not protect that crime would not happen.

But you know that what is happening around that not a great analogy, but I would say that what we are trying to do is one that you have locked the battery with the vehicle, locked the battery with the charger. So the user has no choice, but to come to you to exchange the battery general user, but if it is that intentionally there is a person who is saying that I need to do that vandalism.

And he comes on that then apart from that if you have the trackers inside the battery you can track the location, but once it is gone it is gone. So what they do with the cells, how would they take it out, how much of value they get out of it and how many batteries would be issued to one users in a go is a limited this thing. So what we have done is that we have tried to increase with this method this circulation that happens.

So as a user if I am not able to track or lock the battery think about our cases also if it is that I am allowed to keep the battery forever or I am allowed to charge the battery I will just take the battery, keep on charging the battery and never return him or this could be intentional or unintentional also because if I know that I am not going to pay penalty for it that I got a issue day 1.

I have to return it on day 2 or day 3 or day 4, but if I keep on using it and there is a tracker who knows that the battery is also gone it is 100 percent discharge, but you are just keeping it. So there are two ways of charging the user. One you charge him for the payment for the energy that he has consumed, second you put him the charge for the time that he is utilizing it. So, if it is within 24 hours may be you do not charge him anything.

But he is just forcefully keeping the battery asset with himself you can say that yeah I will charge him based upon the time also. So, those are few things that if you have intelligence and the battery and a mechanism that you can track your asset you can add a lot many layers

of business to ensure that your what to do with your asset, but yeah if you get the user who is actually helped on vandalize it you cannot do anything.

Any intelligence build on that can go for a toss and as far as the packaging is concerned so as per the standards or the protocols that does not specify it has to be a metallic or any other material you can give me a battery with a gold, platinum whatever metal we just specify that how many number of cycles it should be able to provide and it should be able to last that many cycles and that is the warranty that we ask for so we wind up. Thank you so much thanks everyone.