Fundamentals of Electric Vehicles: Technology & Economics
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Lecture - 75
Analytics: Part - 2

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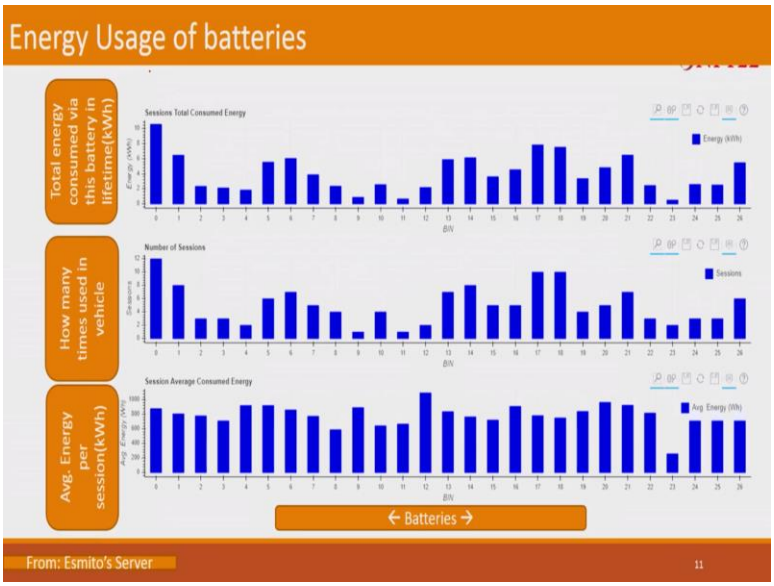

So, moving forward, energy usage of the batteries; there are number of things that we can keep on doing around the batteries. Some more just to show you as an example, one has a total energy consumed via any given battery during its lifetime.

So on the x-axis, if you say, these are see that these are the number of batteries BIN numbers and the energy. So throughout the life, how much energy has been used by each of the battery pack and how would it help me figure out is that maybe the number of cycles that we know that it would work for.

So if we have defined let say, 1000 cycles for the battery, how much energy it has given, and how much has it been used; number of cycles that it has been used. From there, we can roughly calculate. If we do not have good algorithms to predict SoH of the battery. We can roughly, from this calculation, we can figure out that what is the cycles that have been left in the battery. Of course, this is not taken into account the temperature impacts and the other things but the overall count only.

So few simple things that we can do with the data that we have. Then how many times the, the battery has been used in each vehicle or how many batteries have been used in one vehicle. So all these different combinations we can keep on finding out.

Then the average energy per session of charge/discharge. So now, here, this can be done with respect to the battery like it is shown here. We can also do it with respect to the charger. So like I said, the battery would either be charged or it would be discharged.

So while it is in the vehicle, we have to see what is the average energy consumed by that particular vehicle and we can figure out and also compare different vehicle's performances and see that the same battery, when put into vehicle make a or vehicle make b, this runs or gives us better mileage as compared to the other, which means it is basically not the battery performance but the vehicle performance.

And such all different combinations we can keep on comparing, we can see that which vehicle is performing better, which battery make is performing better. Or we can also go to an extent that when this driver drives this combination, this is performing better. So we can also evaluate driver's behaviors from the statistics and the data that we capture.

So whole of this data that we capture can help us a lot around all these subsystems, finally giving benefit to the user. So the ultimate aim is to provide maximization, I mean to do maximization of the asset or utilize, maximize the utilization of the asset, such that you can gain maximum out of the investment that we have incurred in the battery. Either that is me as a user or you as an operator.

So everyone would want that whatever we have invested in, it gives you maximum gains. And of course, you want that there should not be any safety issues.

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A very important part in analytics, where this is very much needed for some techniques to be applied to do life cycle predictions.

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So the first thing, the most important thing when what is relevant from battery's point of view is the SoH predictions. The state of health prediction, where we from all different parameters that we talk about; the voltage, SOC, cell imbalance, and the temperatures, using their entire history to calculate what is the SoH at that given point in time. That means that how much the battery

has already degraded and based upon that degradation, can I figure out the life of the battery left or the state of the health of the battery.

Now here, we would also say that there are people who talk about SoH predictions that they have already done into the battery, which is a good way to do the SoH prediction that is true. But now, why do we need to capture this data and keep it on the cloud, and then do the analytics and talk about its history and geography and everything, and then say that yes, this is this is the SoH of the battery.

The reason is that BMS, we know that BMS is the brain of the battery, but it is a localized intelligence that we have. So BMS does not store the history or the records of the battery. So this takes a decision based upon the local intelligence or the local parameters that we have at that particular time. So what is my current, what is my charge rate, discharge rate; based upon that, I will decide the cutoffs. What has been my temperature, based on that, I will decide the cutoff.

And based upon all these things, at that particular point in time, I will figure out what is my degradation and calculate and send it to the, wherever I want to inform it to the cluster; that is the display cluster or to the cloud, wherever we are sending, we are sending.

But, apart from that, the whole history of usage of that battery, like we said that how much it would stay in 35 degrees or how much it would stay in 25 degrees or at 55 degrees; that will have an impact upon calculating the SoH of the battery. And that is where all these data records become important to figure out or predict the SoH of the battery. And this is one critical, the most critical parameter when we talk from analytics on battery's point of view.

Now, other things are anyways the safety risks and alerts that we can tell. So based upon the history, based upon the profile, based upon what it has been in the lab tested or what is the datasheet that prescribes, so all these things could be the ingredients to do that control part or analytics part to finally give us the result.

So the input to our analytics engine could be the current data that we are fetching, then the data that we had from the datasheet of the battery or datasheet of the cell. And maybe the modeling that we have been doing from the, in the lab. So all these ingredients would help us define our

analytics engine in which we would define all our formulae, permutation, combination, apply whatever ML, AI technique we want to put on that and then give you the final result.

And in the final result, like I said, the most important part for all of us would be how safe we are while we are driving an EV or while we are using a battery and that is where analytics needs to play a role.

So safety and risks again become very, very important part of it where we can define the risk levels also for simplicity of the user and maybe if you are talking about an operator, who is actually offering us battery on lease or it is giving us a swapped battery, exchanging the battery et cetera. So he needs to know that what is the risk associated with that battery, when he gives you or if it is lying with him; if at all there is a risk.

So if it is all going good and I think that majority of the batteries always would be going good, so we would say that there is no risk, go ahead, issue the battery. And the user is also safe, you are also safe to issue the battery.

Low risk, where we say that okay, sometimes we have been seeing that it was in the tolerable limit but it has been put on watch. It could be tolerable limit for the cell imbalance, it could be in the tolerable limit from the temperature point of view, but I am keeping it in a watch; it is still good to go good to use.

Medium risk, where we say that it is really not good to go but should be sent for maintenance. There has to be a good engineer who should be looking after what has happened, what has gone wrong into the battery.

And finally, when we talk about higher risk, when we say that strictly not to be used. If I am an operator, I should not be issuing it to the user. Or if the user is driving in its fixed battery car, then the person should be told not to drive the vehicle or there should be an automated control in many of the vehicles that would be in build that you are talking to the cloud, your vehicle is always connected, and your connection or the operator can control your car at the time of a risk. So it can shut down your car also if it sees that something wrong is going to happen.

And there, further, a lot of intelligence that can keep on building and refining and the accuracies can keep on refining on the analytics side of it.

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So, so far, we have only talked about batteries. Few examples and the few (snap), through the, through few snapshots that we have seen the impact of different parameters that it can take and what it takes to analyze the battery, and why should we analyze that.

There are other subsystems similarly, like motors, where performance of the motors, their life, and all those things you need to monitor it. But for the motors, though we say that it is not a very, very critical element that you need to go, need to analyze because a good motor would give you maybe life-like 7 - 8 years, 10 years also, so you need not worry about that.

But from its wear and tear point of view, from their design feedbacks point of view, or from the critical safety issues point of view, analytics for motors also is important. And for the chargers, lot of thing that you can do around the chargers. If we have connected chargers, connected chargers means where you can capture the data from the chargers for the batteries or its own data also that it keeps on generating.

So the intelligent chargers would make a huge difference in the whole ecosystem; EV ecosystem if we are doing the analytics on the chargers. And then, of course, like I just talked about the drivers and users because they are the important part of the whole ecosystem, utilizing the entire infrastructure. So they are the critical elements who need to be given this benefit of whole of this analytics.

So what are the risks? What are the advantages? What are the disadvantages? What is going to happen and what is a prediction? As a user, I would also want to know my battery in this trip would last for 100 kilometers or 50 kilometers, and accordingly, I need to plan.

So all these things basically are for helping the user and the drivers and the whole analytics should also help me if I can do that. That how do I improve my driving, how should I be driving. So this is only, not only the control part of it but also giving the feedback to the driver; that if you drive at such and such speed on this route, your battery would probably last for 130 kilometers instead of 100 kilometers.

Can I generate such advisories through my data analytics, which is very much possible; it is that if you have that understanding, if we can build up those, all those models around the batteries and the motors, this can be combined together and given to the driver.

Then further, if my driver can tell me, I mean the data can tell me that this driver let us say, take for an example, the case for an STU or a depot, where you have 50 drivers driving your buses. We, we usually see they are not driving good but can our data support that and tell driver A is driving better, driver B is not, and driver D needs training. Yeah? And can we can we give that support to the STU or to other people that we can identify what is wrong with the drivers driving pattern also.

So all this data analytics. So how bad or good he was speeding or he was able to manage that speed, how was he braking, was it a harsh brake, was it a harsh turn? So all those things can be monitored through the whole of the data that we talk about.

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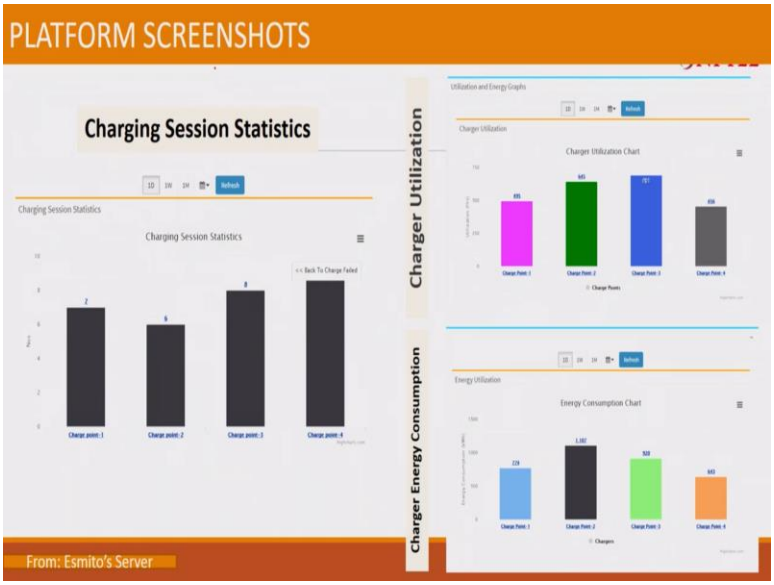

And further, if we talk about chargers, just one snapshot on chargers session. On the chargers apart from getting the data for the batteries, there are simple statistics as well that we can perform around it, which could be very useful to the operator.

So, for example, we talk about in a charging station, how many charging points are put. And those charging points, what is the utilization. So if you are an operator, you want to have installed A, B, C chargers; three chargers. Now, I do not know what should be my fourth charger.

But if you keep a track of that you have installed 7 kilowatt, 22 kilowatt, or a 50-kilowatt charger, these three chargers, what is the utilization of each charger? What is a daytime utilization, what is a nighttime utilization, what is the total utilization? What is the money that you have earned from each of these chargers?

So if your chargers are connected, you can do whole lot of this analytics. And say that for my expansion, I should buy the fifth, fourth charger or the fifth charger of this rating because that is in demand. And if we are, for example, using a swap station, can I know that if I have a 20-port charger, each port is monitorable able and can I figure out that which is a port which is not working and why it is not working.

So the simple statistics itself would keep you giving such important information that your operational expenses can go down. So your ROI is better, we can also plan how to get a good business and keep on planning the rest part of it. So it helps you in maintenance, it helps us in expansion, it also helps us in reducing the downtime of our business. So such simple statistics that we keep on doing helps us a lot.

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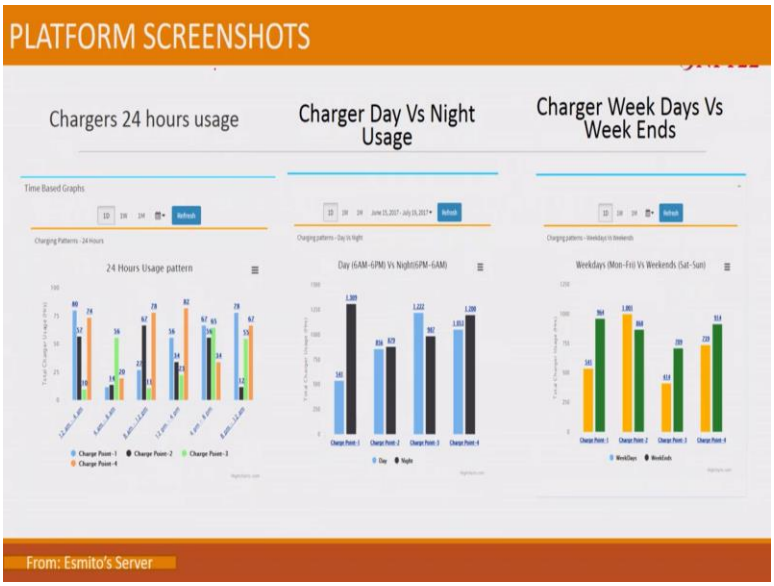

Few more snapshots like I just told, I am not going into depth of each of the x and y axes. Just to give you a broad idea that what is happening during day and night, during 24 hours. And when was the charger down, when was which port down, and how do we go about doing it.

So sitting in one location, so, for example, I am in Chennai, can I see that I installed one charger in Delhi, one in Mumbai, one in Kolkata, one in wherever place. So how are, how is my complete infrastructure behaving? Do I need to send a person physically there or it is good to see the performance here, see the utilization, and plan accordingly. Obviously, I will choose the second option.

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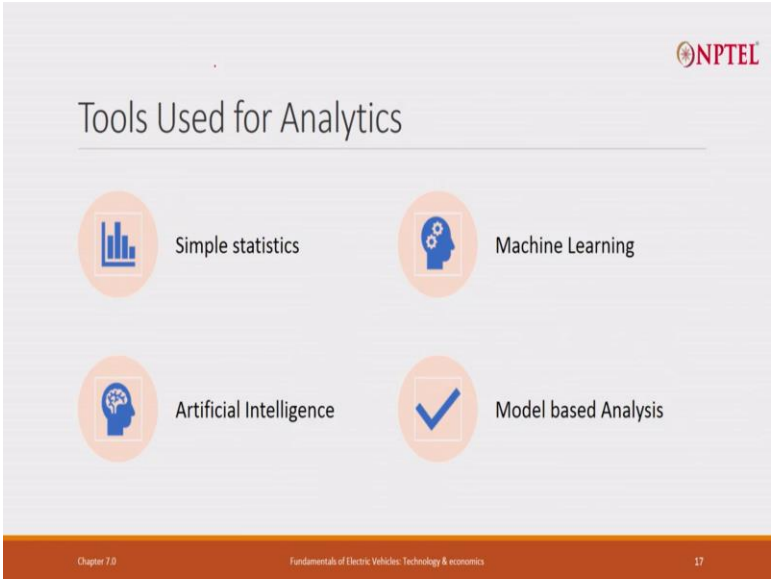

Some of the tools, just to give you an idea on what is it that we require to do analytics. One is only the simple analytics tools that we use, the mathematical tools that we can have, the regression, and all other techniques that we can have.

The second is the machine learning algorithms. A number of techniques that we talk about there like it is neural network or artificial intelligence. For example, we talked about game theory that we talk about, neuro-fuzzy logics that we can implement, genetic algorithms that are kind of a hot topic these days.

So all these different techniques can be applied on the data once you have the data. So there could be that you perform simple analysis, simple techniques on that. It could be that we train the data, so we have some data; we use it as our training data. For example, in our trials, we use that as our training data.

Train the model, get that model in place, and then whatever we are getting through the field, pass it through that model and see that what is the outcome and once you are sure of that outcome, this outcome also moves to your training data.

So you are, as much as your data keeps on getting richer, that means, more the data we have, the better the predictions would become, better the analytics would become. But of course, you need to start somewhere. So that is where the analytics stand.

And the last one is the model-based analysis, where we are not performing any other ML, AI techniques, or simple statistics but it is largely experiential learning where we have, for example, tested the cells, tested the batteries, and based upon these test of that cells or the battery, can I figure out maybe an equation that can solve my purpose that this is the input, apply this formula, this is the output.

So there could be some models that could be formulated. I just said that as a simple line but then, there could be models, there could be steps that you can formulate and say that, yeah, this is based upon this and then, you keep on getting that data and refine, keep on refining that model. So for your next version, next output, this is going to be a revised version of it.

For today, that is all for on the data analytics. So here, we are also closing the course, this was only the last, actually, the last lecture for this course. And hope you all enjoyed the EV and the EV subsystems course. If there is any feedback, please let us know. You can always post your comments as well on the forum or write to us on the given email. Thank you.