Fundamentals of Electric Vehicles Technology and Economics
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Lecture No 2
Can India Drive its EV program Innovatively and Differently and scale? Part 1

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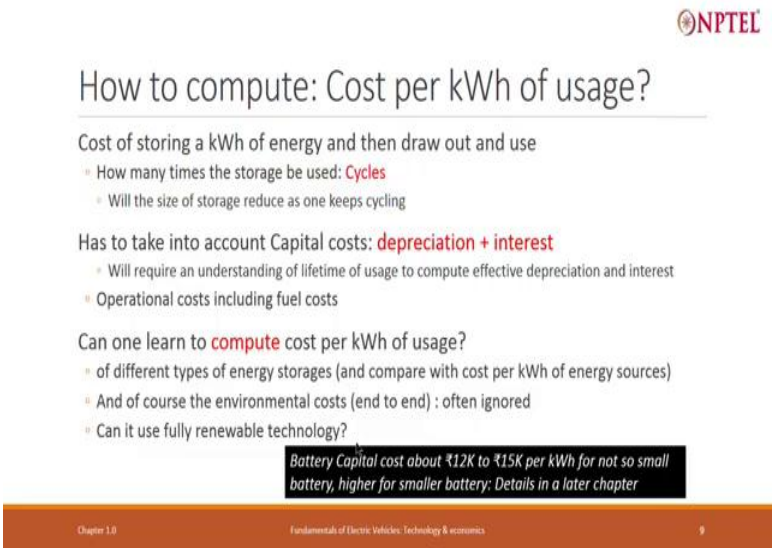

There are large numbers of different things that you will learn. One of the important thing that you have to learn, actually, there is a big difference when you buy a petrol tank, petrol tank is what? A steel box or maybe a Aluminum box, container that is something does not cost much, then you fill up with the petrol, it is a petrol that cost. But, when you talking about electric vehicle, you have a battery actually battery cost, huge amount.

And then about electric, electricity that you put in, electricity cost actually is not large, it is actually for the same amount of energy far less than petrol. We will talk about we will learn what it is. So, there is upfront cost of battery where, is in petrol vehicle upfront cost of tank is very low. It comes in bundled with the vehicle, the bundled with the vehicle, comes up larger battery and the battery containers of cost is very high.

So, this is the capital cost upfront cost but we actually use it all the time. We fill electricity, we charge it, what we call and then we use it discharge it. Then we again use it, again discharge it we keep on doing it and whatever the thing you will learn, that after sometime battery capacity will keep on going down and battery becomes useless. This does not happen in petrol tank, petrol tank the capacity will remain, whatever it was. Battery on the other hand has a certain life, you will have to replace the battery. So, large upfront cost, suppose, you give 100,000 rupees for a battery every time I filled in 1 kilowatt hour and used it, how much

will it cost? Actually this is the fairly complex calculation not done, not understood very well.

I am actually paying upfront but I am using it over may be 4 years. For very kilowatt hour what is the cost? And this involved calculation is learn to deal with it, we have to actually find out how many times can I charge, discharge? What is called cycles, that is called life of a battery, how many times can I charge, discharge? Then, I have to actually. I have paid already for that so, how do I take into account what I have already paid? Well, I have to take something called depreciation, and something called finance cost or interest.

Interest most of you understand, you borrow something with the bank, you have to pay interest rate. So, you assume as if this battery has been purchased from a loan, interest rate, whatever the bank charges that is the interest rate that you have to account for. What about the money that you have borrowed? You have to return that money over 3 years, 4 years, 5 years whatever time, for the life of the battery of you return to the bank. That term, that how much of that battery cost has to returned year after year is called depreciation, in some sense battery value has reduced.

He started with 100,000 may be after year it has gone down to 80,000 rupees it and after that it may have gone down to 60,000 this is a depreciation rate, the economic terms use is depreciation. There is very easy way of calculating depreciation and interest and we will teach you and the depreciation has to be for the life by the time the battery becomes useless and I throw it that time I should have return that.

So, then I buy new battery I have to can take a fresh loan. So, we will have to understand life of the battery we have to understand then the depreciation we have to understand interest rate. And what will be the operation cost? Operation cost of course is the fuel cost, cost of electricity which I told you is there but does not play as important role but we will have to take that into account.

And can we combine all of these and can we learn how to compute, what is as if I am not paid anything upfront what is the cost of usage of 1 kilowatt hour of electricity in car? Then only I can compare it with petrol. How much is the usage, if I am using let say 0.2 litres for a kilometer, I know straight away the cost in my petrol cost let say 80 rupees 0.2 litre will cost 16 rupees and for kilometer it is 16 rupees.

For battery and for charging I have to first take depreciation and interest rate of the battery, that will give me the battery cost plus I have to take the cost of electricity and this will give me a kilowatt hour of usage cost and we will learn how to calculate this. Now, are there other costs? For example, somebody may say are there environmental cost? For example, we burn petrol is their environmental cost?

It is ignored, we do not somewhat pay for that. Same question can be asked, once the battery gets over, his life is over, electricity per say, does not cause the direct impact on environment, indirectly one may say generation electricity has impact, we will deal with that separately but, battery once it is over you threw it away.

Is it a waste is, there environmental impact? We will deal with that also but it is often ignored. So, similarly one can say are we going to use electricity from coal, then there is a environmental impact of the coal also or if I am going to use it from solar and wind, the environmental impact is very different.

Our objective will be tomorrow to use battery which is fully recyclable, which does not a impact on the environment and electricity from renewable energies solar and wind such that, the electric vehicle becomes fully renewable energy, that is what, and we will learn in this course what we have to do. It is not easy but it is very much doable and this is one of the thing that we have to do.

To just get a feel of it today the cost of a battery somewhat large size battery not a very small battery, is above 12,000 to 15,000 rupees per kilowatt hour this is a capital cost. For let say 5 kilowatt hour battery may be around 60,000 to 75,000 rupees per kilowatt hour, for 5 kilowatt hour. We will actually learn how to compute this, what does it really mean, we will learn each of these things in detail.

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This is what I have done as part of first chapter, I will now move to the next chapter. You do have many questions on the first chapter? This is the first section in the first chapter, I have not finished the introduction. We are now going to see, get little more in depth into the electric, the vehicles in India. And my proposition is that India reach to drive its electric vehicle program differently and innovatively to scale. And the reason is if we look at the characteristics of Indian vehicles, there are two characteristics that you will find, that small vehicles dominate.

Number 2, affordability dominates, therefore, our vehicles requirement is different from that required in let say Europe or United states. So, since we are going to introduce electric vehicle where battery is going to the large cost, one has to actually deal with even the electric vehicles keeping in mind that we need small and affordable vehicles, to just look at it.

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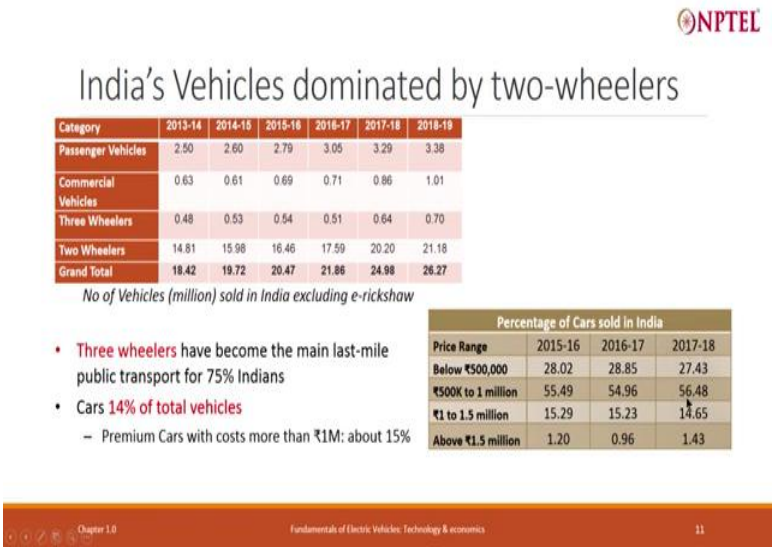

Look at the number of vehicles that we have sold in different year from 13, 14 to 2018, 19 and look at the later 2018, 19 and you see, that almost 80 percent of the vehicles are two wheelers. That is not so, in most of the countries. Then there are three wheelers, e-rickshaw is not been included here, otherwise it would have been little more and then there are some commercial vehicles and then there are cars.

So, the cars are only 15 percent. That is a first thing that we will notice, most of it is two wheelers. The second aspect that you will see and three wheelers are very important because, they have become the last mile transport or public transport for most people. Because, buses are there only in limited number of cities, a lot of people actually travels by three wheelers so, three wheelers are very important.

Now, if I want look at these cars, passenger vehicle cars, this is above 14 to 15 percent. Here also look at the numbers, if we look at this is in percentage, if you see 27 percent of the vehicles costs less than half a million rupees or 5 lakhs, 57 percent or the 56 and half percent of the vehicles costs between 5 lakhs and 10 lakhs which is between 0.5 million rupees to a million rupees. So, if we look at it almost 84 percent vehicles are less than a, million rupees.

And even if you go above a million rupees, a million to 1.5 million you still have (15) 14.65 percent and very very few one and half percent or even less than that above 1.5 million rupees. The reason I am emphasizing is that if you go to Europe or United States the lowest cost car will exceed these 15 million rupees which is about 2000 dollars, 20,000 dollars not 2000 dollars, they will be above that. Whereas in India, either it is a two wheelers, or three wheelers or cars which are low cost that is the dominant percentage of vehicles.

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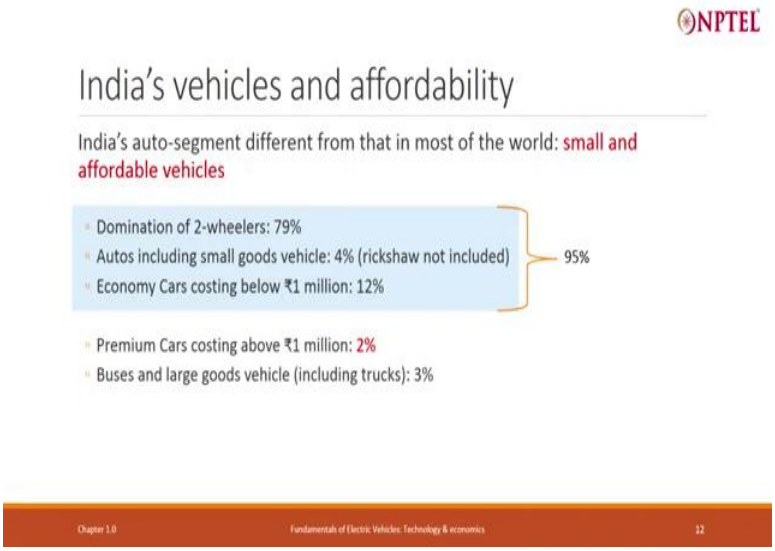

And I putted out here, if I look at in India two wheelers, the autos and small goods vehicles and economic cars costing less that rupees 1 million. It will be about 95 percent of the vehicles. And the India's strategy has to be it is this market that we should capture and we should win, we should be ahead of others our vehicle should be better and yet low cost similar to the cost that are today people are purchasing.

The reason our affordability is low, simply is because, our economy GDP is low they can only afford that much amount you cannot push them and say ohh, now buy more expensive vehicles they will, buy the same 40,000 to 50,000 rupees to 60,000 rupees two wheeler and half a million rupees to 0.6 million, 0.7 million rupees for four wheelers. That is where the dominate market is. And our electric vehicles has to more or less match that numbers that is what has to be done, and it is this that we should become very good at.

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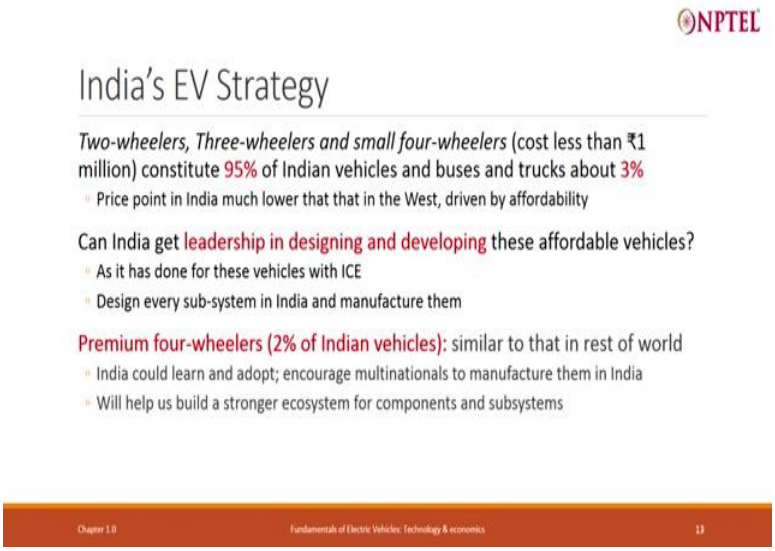

And we should become the world best and for the high range vehicles, well it does not really matter we can learn from the west, we can borrow from the west, we can adopt what they are doing, I mean they are doing some excellent work, let that happen largely has a transfer of know how from the west. But, for small vehicles we have no option.

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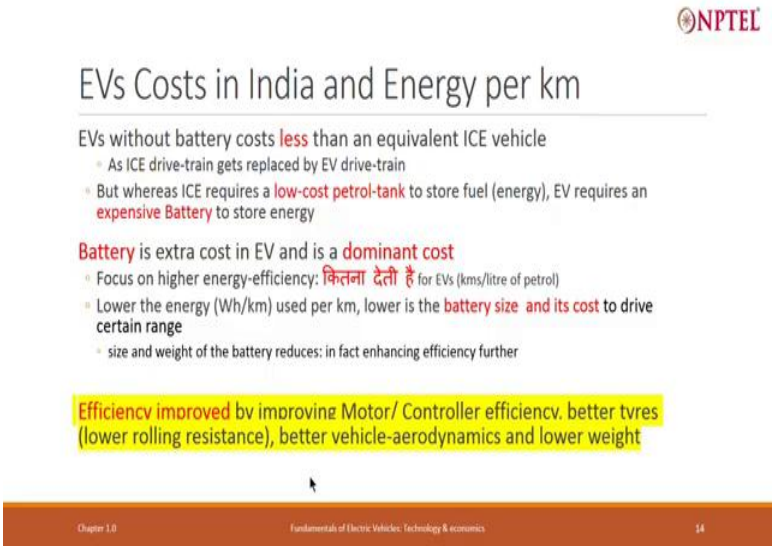

The other very important question will be the same question which I asked earlier, EVs cost, cost of capital cost when we talk about 500,000 rupees car or a 50,000 rupees two wheeler and the operation cost the cost of energy per kilometer. Now, one thing that you will notice right in the beginning that without battery, without battery electric vehicle cost will be less than a internal combustion engine vehicle or petrol vehicle.

As soon as we include battery the whole scenario changes, expensive battery to store energy. So, battery is extra cost and dominant cost therefore a significant part of the battery cost, our thinking our focus will be how to reduce that cost. There is a very interesting slogan that capture the imagination of people in India it was a slogan that was given by Maruti, for its cars and the slogan that was given was “Kitna deti hai?” You must have heard about that.

How much what is a mileage? Why was that slogan caught the imagination because, for middle class people want to buy the vehicle, the cost of petrol was really pinching. And if it give larger mileage, more umber of kilometers per litre cost will come down. And that caught the imagination most other, manufacturers also focused on what is called energy efficiency. So, with the mileage or energy efficiency the mileage term became common to energy efficiency? What is a equivalent term and does it real matter?

We will show you, it does matter. The equivalent term for us is watt hour per kg, per kilometer, sorry watt hour per kilometer. How many, how much energy is used per kilometer of travel? What will happen if I have better watt hour per kilometer, sorry less watt hour per kilometer, if I use less watt hour per kilometer, my size of the battery required becomes smaller. And if the size of battery becomes smaller my cost goes down.

So, focusing on reducing watt hour per kilometer, remember earlier we talked about watt hour per kg, that was the property of the battery, cells, here it is a different so, property of vehicle. Can I consume less energy to travel 1 kilometer? How much watt hour per kilometer I travel? Lower it is lower is the size and weight and the cost of the battery.

Now, if I have a lower (()) (18:17) cost, lower weight, there is another thing happen, the energy efficiency of the vehicle depends upon the weight, how much watt hour per kg depends on the vehicle weight and the vehicle weight of course is the, weight of the vehicle per say the people, the luggage and everything else, plus the weight of the battery.

Weight of the battery is considerable if I have a less, smaller weight battery, my energy efficiency improves, watt hour per kilometer improves. So, it has a double effort, effect first I reduce watt hour per kilometer, that means my battery size become smaller, once my battery size become smaller, my watt hour per kilometer further goes down.

Therefore, to make electric vehicle viable in India, I will say the first technology program, first R and D program is, how much we he reduce watt hour per kilometer or start asking the

question for electric vehicle, “Kitna deti hai?” This is something that was not understood for long time, actually it is not a significant for the west this question.

Why because, the affordability is much higher, in fact “kitna deti hai”, Maruti slogan came in India and not in Japan, it becomes advantage in India. So, even for electric vehicles the question that we have to ask “kitna deti hai”, instead of a litre of petrol we talk about a kilowatt hour of battery. That is the first thing which will efficiency improved by improving and how do we improve this energy efficiency? Simply, improve the efficiency of motor or controller, that helps in improving.

How do we improve a further, better tyres, better tyres helps. We will talk about it we will show what is called a rolling resistance, if I get a tyre with lower rolling resistance it improves the energy efficiency. Better vehicle aerodynamics, aerodynamics will play a very important role in the energy we consumed and we will actually calculate. If I improve my vehicle aerodynamics which it will improves the energy efficiency.

And of course if I reduce my weight, how do I reduce my weight? Well, I cannot reduce the people weight, I cannot reduce the weight of the luggage that they have. I can only reduce the weight of the vehicle. Can I use different material to reduce the weight? Of course reduce the battery size that reduces the weight. So, this, the program for the, we know how to improve energy efficiency or “kitna deti hai”, have our watt hour per kg.

There are 4 things, improve efficiency of motor and controller, this will be one of the major focus in this course. Better tyres not the major focus of this course but that we want to know, better vehicle aerodynamics again we will not get into detail of vehicle design, this is not course of vehicle design. And lower weight, which to some extend means can I improve my battery, my watt hour per kg improve the battery efficiency. This is what we will try to do.