Fundamentals of Electric Vehicles: Technology and Economics
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Lecture No. 36
Standardization and On Board Chargers

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My next chapter is very small chapter, Standardization: Why and what? What is standardization?

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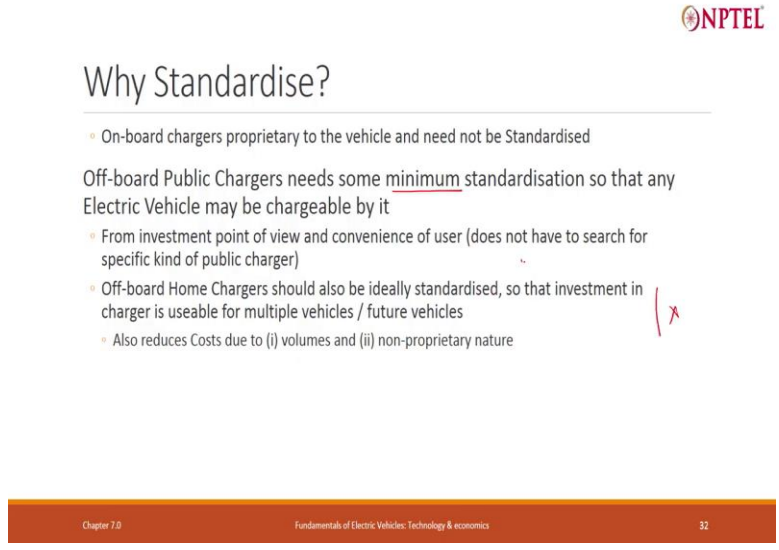

Very often people have not understood what needs to be standardized. Why is standardize? On-board chargers proprietary to the vehicle and need not be standardized. So, on-board chargers

you just connect it to 230 volt or 3 phase, need not be standardized. On-board chargers is not going to be used by multiple vehicles, only going to be used by, by one's own vehicle. Off-board public chargers, I am first talking about chargers, we will later talk about batteries, swapping. Off-board public chargers, I put a outlet whether I bring Mahindra vehicle or Tata vehicle or any other vehicle, I should be able to charge.

So, it need some minimum standardization, remember I am talking about minimum standardization, not maximum, maximum standardization can always be done, everything is standardized. But then the competitive spirit will go away. We (())(1:26) make minimum charger standardization, so that charging business and swapping business make sense. So, then only the energy operator will invest in chargers and provide more convenience to the user. The user does not have to search, there will be more such chargers where they can go.

Off-board home chargers should be ideally standardized, so that investment in charger is usable for multiple vehicles, once I buy a on-board charger, why should I have to keep on buying? But well if it is not standardized, it does not matter. It also reduces cost due to volumes and non-proprietary evaluation. And yet we are not going to talk about this, we are going to talk about public chargers.

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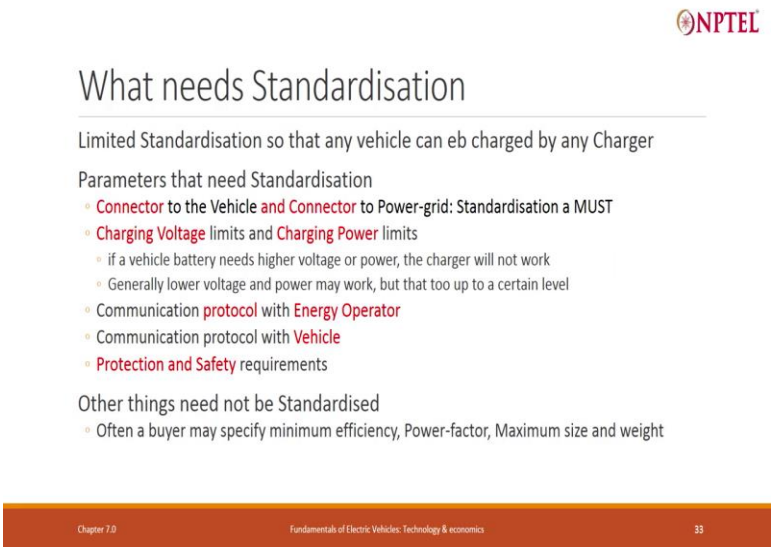

What needs standardization, this is important. Limited standardization so that every vehicle can be charged by any charger; that is all. And what are the parameters that need standardization?

First is a connector, connected to the vehicle, connected to the power grid, standardization is must. Connected to the power grid, all 15 ampere connectors are standardized today for electricity in India, in every country it is standardized. That is similar, we are sort of saying if you are going to draw power from the grid, should use standard connector, could be a 15 ampere, could be a higher, bigger connector for 3 phase should be standardized.

Similarly, on vehicle side you need another connector, you need connector one two sides, that should also be standardized. And remember you will be putting in the connector, taking it out large number of times, so it should have some rigidness and life also. Second is limits of charging voltage and charging power, limits, power and voltage need not be standardized, one can say any voltage between 200 volt to 700 volt, that is a standard.

Now as long as the vehicle battery needs between 200 to 700 volts, you can put it in, it can communicate, communication will take place between the vehicle and the charger, and it will set the voltage that the vehicle needs. Should be, limit should be standardized, it cannot be that the charger has only one range of voltage and then somebody comes with another range of voltage. So, you can say it will less than 700 volts, it will be less than 200 volts, any vehicle battery which has less than 200 volts will work.

Sometime there may be a lower limit also, you may not, if somebody wants a 24 volt, may not be a good to charge with that. Communication protocol with energy operator, in the charger, the charger and communication protocol with the vehicle, remember the vehicle and the charger has to talk to decide what voltage what power, it must be a standard. That is a communication protocol, that is a that is what, protocol is essentially a software, the language that they both understand.

Similarly, a protocol with a energy operator, you are going to communicate with the energy operator, I am going to draw 50 kilowatt hour power for the next so many minutes, please allow me to. Grid says, no, no, no, I will give you only 20 kilowatt, reduce, that needs to be standardized. What is the amount of charging, I will say (())(5:19) you are trying to draw more power, I will charge you 8 rupees per unit, so that needs to be standardized.

What also needs to be standardized is protection and safety. So, to ensure that there is a protection and safety. So, essentially you need connector, maximum voltage and power,

communication protocol, and protection and safety, that is all. Other things need not be standardized. What is the efficiency of charger? While it matters, finally vehicle battery will be charged, of course more energy is used. Power factor, now grid want some power factor but need not be standardized. Maximum size and weight of the charger need not be standardized or for the battery.

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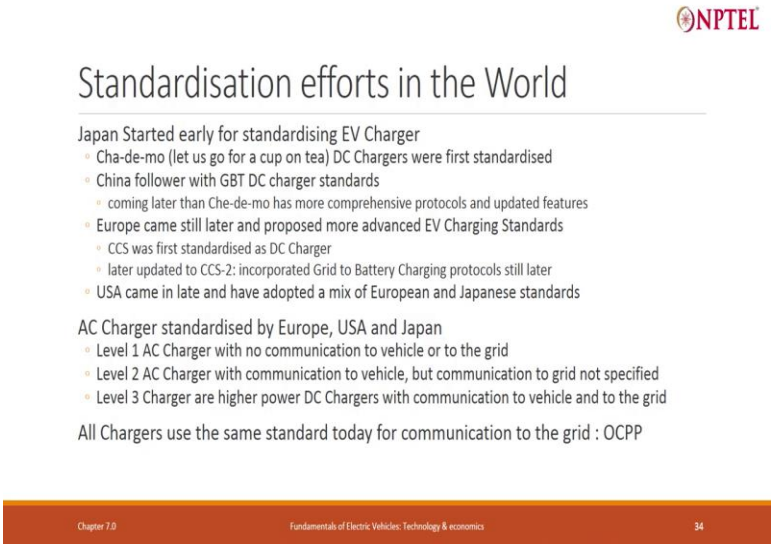

What are the standardization efforts in the world? Japan started early for standardizing EV charger, the Cha-de-mo as I pointed out let us go out and have a cup of tea, DC chargers were first standardized. This was followed by China, it came off with its own standard GBT, connector was different, the protocols were different. Coming later than Cha-de-mo, it is more comprehensive protocols which is able to add more protocols and features.

Europe came still later and propose some advance EV charging standard, CCS was first standardized, then it became CCS2. Today CCS2 is the most, the highest uses charger, so there is a Chinese charger, and Japanese charger and European charger, and then there are mix, US has come with a mix of all these. India is also looking at the mix of all these. Remember there are two kinds of charger, one is a AC charger, what is a AC charger? Where AC charger, you take AC socket and connect it, use on-board chargers, charger is built into the vehicle or put inside the vehicle.

So, there are 3 common standard Level 1, Level 2, Level 3 AC charger. Well Level 3 is also useable by a DC, Level 3 is also, Level 3 are higher power DC chargers with communication to the vehicle and to the grid. One thing good has happened, while each of the country has tried to put different standards, just like the plug points, if you look at plug points are not same in different countries, if you visit another country you have to carry all those adapters.

In the same manner, the chargers also they have not standardized, but one thing everyone standardized communication to the grid will be only OCPP. This was decided by different people and everybody has worked on OCPP. So, at least grid does not have to worry about it, it can have a single protocol.

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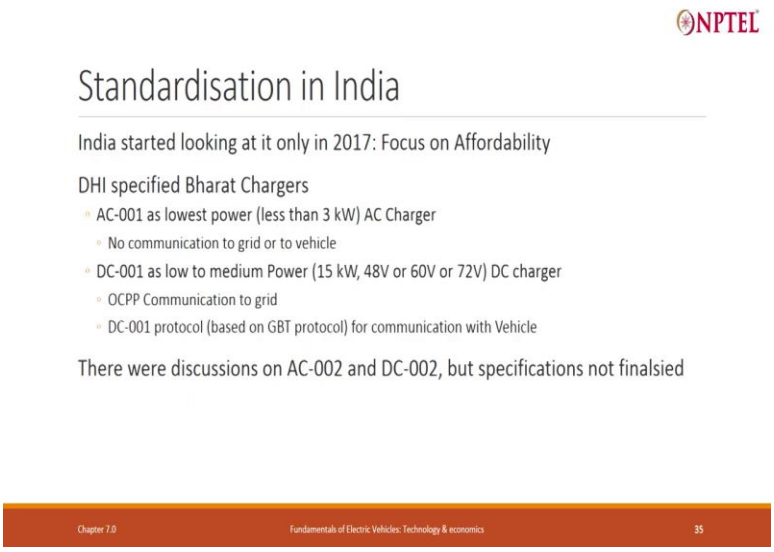

India started looking at only in 2017, in fact we were involved and one of the key is true in India was will the chargers be affordable? Will the vehicles be affordable? So, there 2 standardization took place and we will get into more detail later on, one is AC001, it is a simple plug point, say industrial plug 15 ampere, you connect to single phase, you connect it, you can have 3 phase for 3 chargers, so a single phase for a charger, it is a 3 kilowatt AC charger.

The second was for a low end vehicle, up to 15 kilowatt charger, DC001, it is called DC001, it was designed for 48 volts, 60 volts or 72 volts, it was not for higher voltage, because the vehicles only had batteries which were 48, 60 or 72, and it is 15 kilowatt, 15 kilowatt not high. OCPP communication was to the grid and to the vehicle we used a modification of DCG of GBT

charger, the Chinese charger and even the connector was a modification of that. This standardization effort also discussed AC002 and DC002, saying that higher end AC charger, higher end DC charger, but specification should not finalized, this is the standardization in India.

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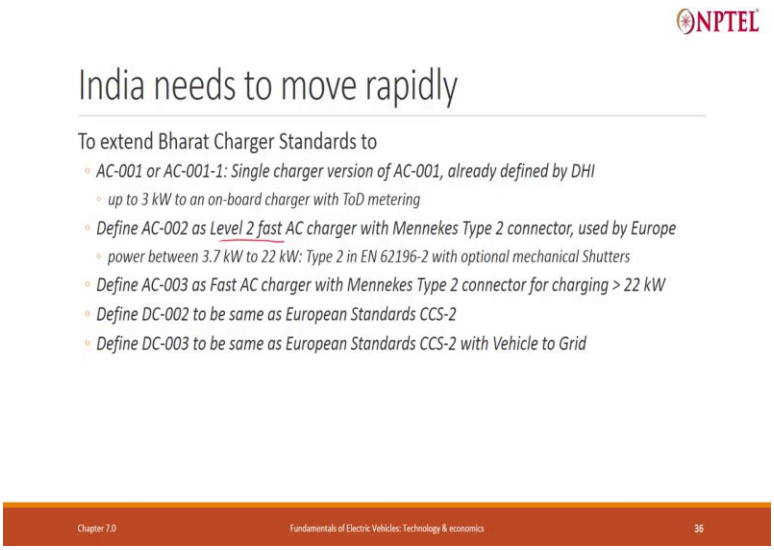

So, India needs to move rapidly, AC001 or AC001 dash 1 can be a 3 kilowatt AC charger, you should define a AC002 charger as Level 2 fast AC charger, maybe with Mennekes Type 2 connector, it is used in Europe, it is used in US, this can be adopted. It will give you between 3.7 kilowatt to 22 kilowatt. AC003 will be a fast AC charger, so it could be higher, it can look at it. DC001 is already defined, it can be DC002, I would say one can use CCS2 and because European standards are most commonly followed in India, another could be DC003 which is CCS2 plus vehicle to the grid.

So, this kind of standardization can be done, of course we can only recommend that but there are different bodies which are at longer heads and they are not getting standardization done.

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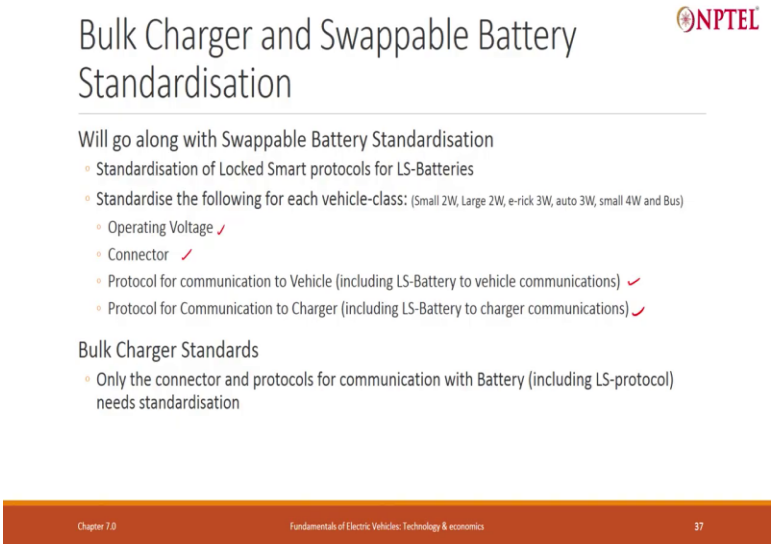

What about bulk charger and swappable battery standardization? So, it is desirable that swappable battery standardization is done, first locked smart battery protocol should be standardized. For each vehicle class like 2 wheeler, 3 wheeler, 4 wheeler small, 4 wheeler large, we need to define working voltage, operating voltage, connector, protocol for communication to the vehicle, protocol for communication to the charger, that is all that been done. And for the bulk charger only the connector and protocols for communication to the battery is required, needs (standardi), nothing else. And this will be discussed in detail later on.

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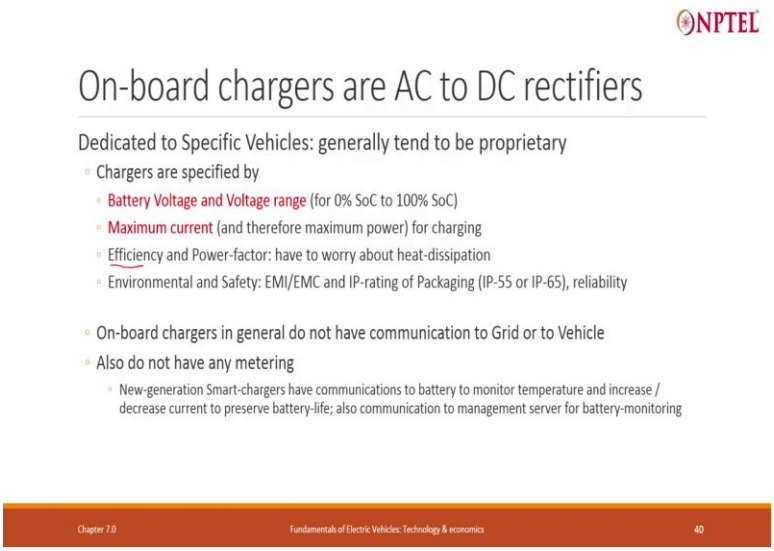

There is an assignment and I am done with 7.4

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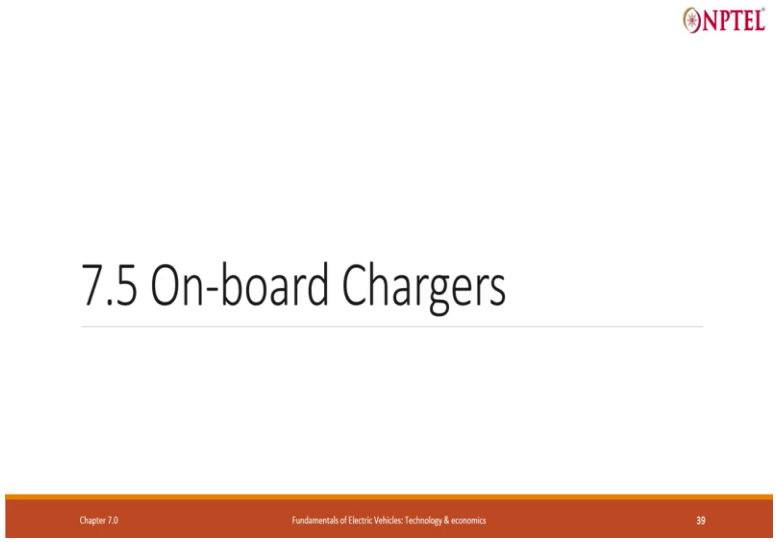

I will come with a very, very small section called 7.5 on-board chargers. On-board chargers remember are the chargers that are put with the vehicle.

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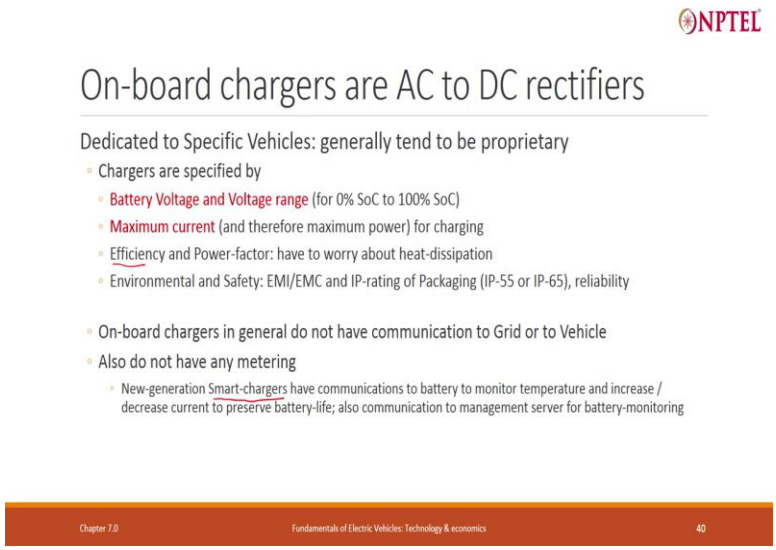

They are essentially AC to DC rectifiers. It is dedicated to specific vehicles, generally tend to be proprietary. What are chargers specified by? Battery voltage and voltage range at 0 percent and 100 percent. Maximum current, which will of course voltage into current will give you maximum power. Efficiency and power factor, why? If it is a 90 percent efficiency, heat

generated will be less, if it 95 percent it will be even better, if it is 80 percent heat generated will be more.

Power factor is also important to that extend, if I am using public power, I may actually have to pay extra to the grid because they will insist on 0.98 or 0.99 power factor. And of course one has to also worry about what is the safety and environmental aspects, EMI, EMC, IP rating, IP55, IP65. This is the for the on-board chargers this is the standardization that one may do. On-board chargers, they generally do not have communication to the grid or to the vehicle and also do not have the metering.

On-board because I am connecting to my private connections, I do not, the charger may have the metering, I will not have to have, the external plug point may have metering. Now there are new generation smart chargers which have communication to the battery, these are very interesting, they will communicate with the battery to figure out is the battery getting hot, are the cells imbalanced. Because the charger will then not charge as rapidly, it is for better management of battery, better life of the battery, these are called smart charger, these are just coming up.

Otherwise the on-board chargers basically, you have to define voltage and current, maximum current, your (desig) fine efficiency in power factor and finally the cost because these are dedicated, every vehicle has to have it. It is not as if one charger is shared by 30 vehicles.

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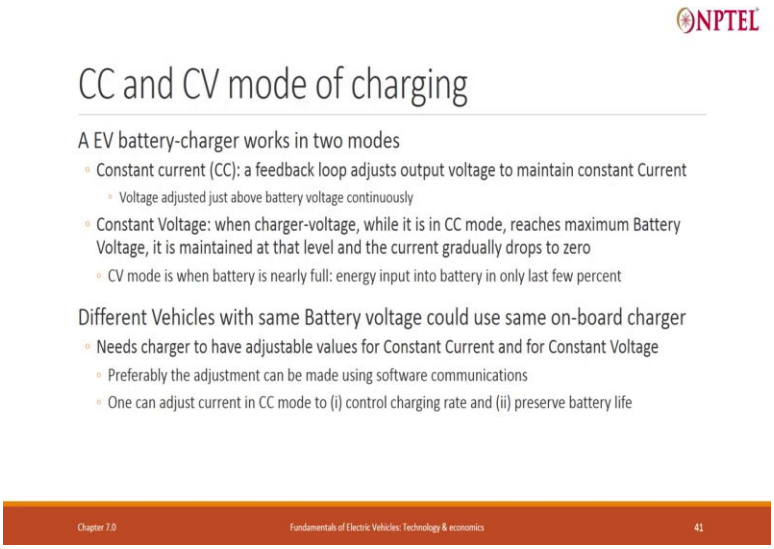

Student: So, the public charger will not be supplying DC, they will supply AC?

Professor: Well there are public charger DC, public charger AC, that will be done in the next thing. This is the on-board charger or you may use there are on-board charger and connect to AC or you may directly use a DC charger. A EV charger normally works in two modes; constant current, constant voltage. We have gone through that repeatedly; constant current is where you will be charging the battery at 0.5C, 1C, 0.3C.

And constant voltage, once it reaches the maximum voltage, you allow it to float and give some more charge, and constant voltage mode is went back to it is nearly full, energy input to the battery is only last few percent. Well it depends, if you are using fast charging, it can be a lot. Different vehicles with a same battery voltage could use same on-board charger, now that is a big advantage.

Because now volume will build up which will mean cost will come down. There are chargers where you can adjust the current and the voltage, there are chargers where (())(16:41) is fixed, there are chargers where you can adjust. Now these are healthy, you like the chargers, on-board chargers where you can adjust and there can be auto adjust, that is a smart charger, we will say well temperature is high, I will charge very slowly. So, in constant current normally you can charge at higher current low current and software communication.

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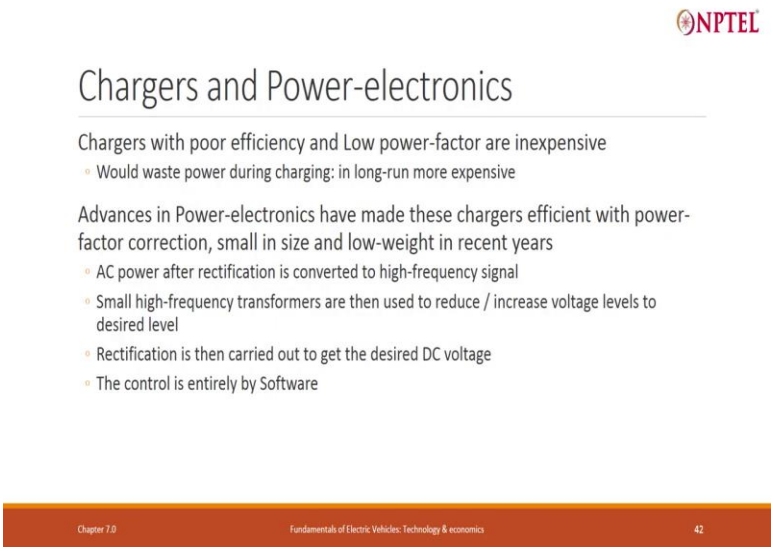

Chargers with poor efficiency and low power factor are inexpensive, so you can get very, very low cost charger. But what does it mean, it is a poor efficiency, so you are burning lot of heat.

Normally you find, suppose you are using charger 50 times, you will see, you have spent as much money in electricity as you would have bought a higher efficiency charger. Yet lower cost chargers are attractive, you are burning more power, you are paying there, you do not think of it, upfront cost, you do not want to pay 2000 rupees, you want 1300 rupees, in long run more expensive.

Now advances in power electronics have made these chargers efficient with power factor corrections, small in size and low weight in recent years. So, this has happened, cost slightly higher, only slightly, the cost between the two also is going down. AC power after rectification is converted to high frequency signal, so first thing is a simple full bridge diode rectifier, after that you convert it to high frequency signal, high frequency transformers are used to reduce or increase the voltage levels and then rectification is again carried out and the whole process is controlled by the 6 software.

This is the way today chargers, new generation chargers are made, old generation chargers did not used to made like this where you use 230 volts, 50 Hertz and you first put a transformer to reduce the voltage and then rectify it, the transformer used to be bulky, expensive and there used to be huge losses. This is the new generation chargers. Pretty much done. Thank you very much.