Fundamentals of Electric Vehicles:
Technology and Economics
Professor Ashok Jhunjhunwala
Indian Institute of technology, Madras
Lecture 6
Where will we get Lithium for batteries?

Another question that is sometime posed by us, in fact I was posed this question repeatedly 3 years back by government authorities. This is great, you are working on electric vehicles, it means that we do not have to import petrol that is very good. It will significantly impact positively our economy. What about batteries? We said battery will make it here in India. Then we said what about the material for the battery? What are the materials used for the batteries?

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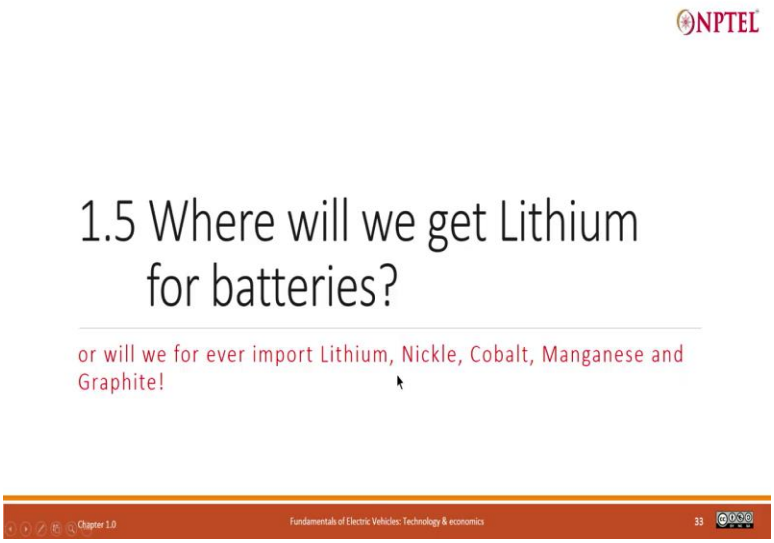

Primarily lithium, nickel, cobalt, manganese and graphite. Lithium, nickel, cobalt, manganese and graphite, these are most common, there are some other materials. Do you have these materials in India? Unfortunately not. So, the question that was repeatedly posed to me, while you will replace oil import by import of nickel, manganese, cobalt, what is, it does not look attractive enough.

I kept on saying, wait we will figure out what we have to do. And I am going to present to you where did lithium, will get lithium. The problem was right in that time when we are just starting to understand this people say no, no, no stop it till you figure this out. While you are importing

oil there are other benefits other than imports, we should have started this and figure this out. Anyway we had to figure it out because many government agencies will not allow you to go one step forward without figuring out something that you will require ultimately.

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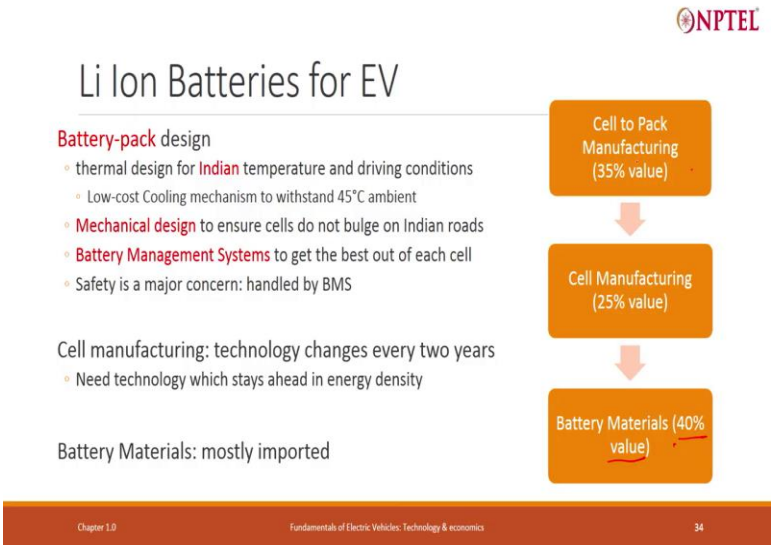

So, let me spend a few minutes on what constitutes a battery. Again something which we will get into details later on. The battery constitute, the value of the battery constitute of three things. One is battery material, this is about 40 percent of the value of the battery comes from this battery material and this is as I have pointed out a lot of it is lithium, manganese, cobalt, nickel and graphite.

Then using this material cells are manufactured, that cell manufacturing is about 25 percent of the cost and then using this cell battery packs are made and this is 35 percent, sometimes slightly higher cost. So, to comprehensively answer those government officers we have to figure out each of these things.

Yes, 3 years back we are just importing the batteries, the packs which constituted the cells, which constituted the materials. And we said what we need to do is step by step figure out how to use make them in India. So, let me start with battery pack design, the top part which is 35 percent of the value.

I will give you example, for example, similar kind of questions were raised about the cell phone. Cell phones we were completely importing, 5 years back we were completely importing this, 6 years back. There were some people who were selling in India but they were importing and rebranding it and selling (())(4:11).

Let us take the first step can we at least start assembling the cell phone? That value is small 7 to 10 percent, but at least that much, anyway we are going to import, so can that much at least jobs be created, can that much work be done in India? And today we are very proud that today India not only manufactures, assembles most of its cell phone, actually lot of it in Chennai region, Tamil Nadu, but actually assembles even for the significant part of the world.

So, while we are may be doing only 7 percent value add for our phones but we are probably exporting double the number of phone, so strictly speaking we are equivalent 21 percent, 20 percent value that we are already doing, that is a step forward. Ofcourse that is not good enough. The next question will be that can we do one more instead of just mere assembling, can we also make the components?

And then we go into each component and say, okay we can now do that and that from 7 percent we have gone to 20 percent, from 20 percent we can go to 30 percent, 40 percent step by step. So, we also said let us start with sell to pack. Initially people thought that it was a trivial thing till we figured it out.

Battery pack design is a huge engineering work. First reason why it is a complex task is there is a thermal design. Remember that I talked about life of the battery depends on the temperature and when battery is going to be charged or discharged whenever it is going to be used temperature is going to increase.

So, the question came, can we do thermal design for Indian conditions? At 45 degree centigrade will it work? Now, remember that most of these EVs R and D actually was carried out in colder countries, whether it was Europe, United States, China, Japan, they do not go to 45 degrees, for them 35 degrees is hot. So, the batteries were designed only for that, we said can we design it for 45 degrees or maybe even 50 degrees.

So, thermal design is the first task that we started doing, it was tough but we figured it out. We may have to do low cost cooling mechanism depending on the size of the battery, you may have external cooling or just let it cool by itself, heat dissipation you can do better. Remember if you do thermal cooling by let us say some either blowing air or passing it through liquid you are actually using energy and that energy also will come from the battery, so you will actually partly consume the energy or the battery to just cool.

So, in some sense you have a larger battery pack but is effectively a smaller battery pack. So, that is not the most desirable thing but you may have to do for a car battery you have to do cooling, for a two wheeler battery you probably do not have to, you have to design it with heat dissipation so that it can work.

The next important thing is mechanical design. You know all these cells that come you need to assemble them and you need to fasten them. The problem with these cells are, as it is used these cells seems tends to swell up. When it swells up the life of the cells go down, so you cannot allow swelling beyond a certain point.

You need therefore very careful mechanical design that light up that puts right amount of pressure to not allow swelling beyond the point. If you put more pressure you again impact the life of the battery. Remember the objective of a design is always to maximize the life of the battery. So, the mechanical design has to be very carefully worked out plus the complication.

You know our roads are very often, very rough, some of the roads are totally broken and our vehicle travels on those roads and the tremendous amount of vibration takes place. At that time the battery has to be so designed that every cell gets a uniform pressure and is not impacted, it requires careful mechanical design.

Then it requires very careful electrical design, we will actually later on learn that batteries invariably have large currents flowing, 100 ampere, when large currents flow even the smallest difference between resistance can make a huge difference. If you have two parts and one part has slightly lower resistance most current will flow through that and you will get a certain drop, another path should have gone but current does not flow enough.

So, you have a very careful electrical design because this will tend to make the cell imbalanced, there are multiple cell, some cells will be more used, some cells will be less used there is what is called cell imbalance. If there is a cell imbalance the problem that you will find the life of the battery gets tremendously impacted. And finally the most important thing is what we call battery management system BMS.

Actually you have to therefore take and monitor each cell. Now, battery pack may have 100 cells, maybe 300 cells, sometime large packs like Tesla's packs have thousands of cells. And if any cell gets impacted the whole battery will get impacted. In fact a failure of a cell may make the battery not work, depends how it is configured.

And the life of every cell matters and every cell is dangerous, risky if it temperature goes up it can blow up. So, there may be 300 cells and you have to monitor each and every cell, you have to monitor, you have to monitor the temperature of the cell is it getting heated up, very risky.

You have to monitor the current flowing through the cell, is more current flowing through a cell rather than to the other. You may monitor the voltages of the cell, is it getting under voltage, is it going to get cut off, how much energy is left you have to monitor that. And you have to do what is called cell balancing, sometime one cell will get more electricity, so you may have to do balancing.

So, it is actually fairly complex task. At one time I remember first time I saw the batteries being made I saw some of the designs that came from Germany, I went to a German company where they were making and they were making absolutely high quality batteries. That time I had also visited some US companies, they are making BMS and battery pack not as good, Chinese were making it but 4 years back even worse, India had not begun.

Today fortunately very good designers have stepped in and are able to make good BMS, good pack, where in Indian designs are as good as German designs. This is a strength so the pack something that we had learned to design and we know how to manufacture, we are already ready to do 35 percent value add in all the packs. What about cell manufacturing?

Now, one of the problem with cell manufacturing is, it is a first of all high investment, it is a chemical plant, but costs are large. You are talking about several hundred crore rupees to set up a

plant, it is a chemical plant. So, it is not a small business. What is more important, you remember that I mentioned that energy density of the battery is continuously coming down, how does it come down?

The battery chemistry slightly changes, so the battery chemistry is continuously evolving and if you start and set up a plant for one battery chemistry and it evolves and you cannot make in the same plant with another chemistry that plant becomes useless or if you are not even access to the next generation chemistry again that plant becomes useless.

So, associated with the cell manufacturing has to be a R and D to keep ahead and make the best battery at a time. This is a somewhat difficult job, there are few organizations in India which are doing work in India, I would sort of say the best strategy will be getting to joint venture with some maybe even international organization which makes batteries, cells and we can then capture 25 percent, there is no big deal, not complex, the chemistry makes it complex.

Fortunately enough number of Indians all over the world are working in this, we can capture that, it is a high investment plant, many of the chemical plants are, maybe a oil in companies the ones which are setting up refining of oil can set this up. Many of the pharmaceutical companies are very similar, so one can do that. What about battery materials? Today it is mostly imported.

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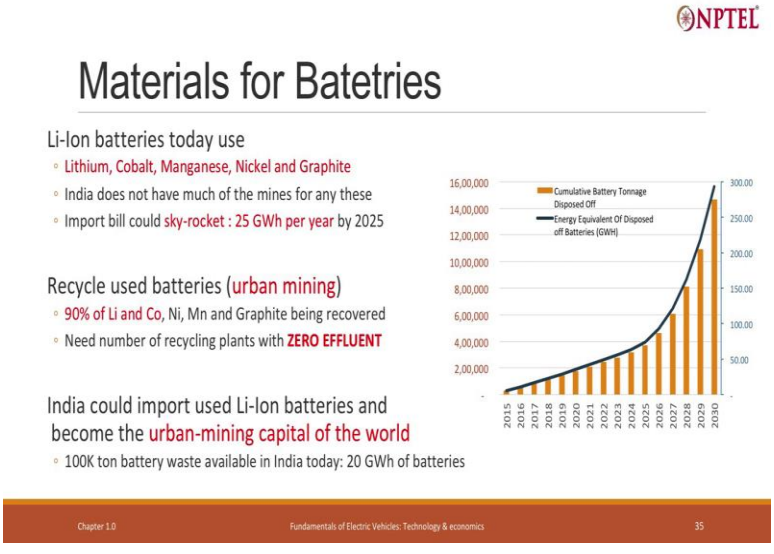

And as I pointed out, we are actually using more and more materials and here is a projection of how much materials that we are going to use. We are already using it in cell phone these materials, we are using in laptops and tomorrow we are using electric vehicles. And we will almost require 25 Giga watt hour of battery material by 2025 per year. This will be a huge import.

Fortunately within India some young companies figured out that I can take a cell phone battery, used cell phone battery, a thrown away cell phone battery and I can open it, I can extract the materials, I can extract lithium, manganese, cobalt, nickel, graphite. And it was found that almost 90 to 95 percent of that material can be extracted and the materials are materials, nothing goes wrong with those materials, they can be little bit processed and reused.

And most interesting thing is with carefully if you do it you can do it totally with zero effluent, no liquid waste, no solid waste, no waste in gaseous form, it is a complex technology, it is a somewhat has to be done carefully so that there is no effluent, without effluent it is easier to do, if you allow effluent to go, but you do not want to pollute.

So, it is possible in India to actually do this in large quantity, what I call urban mining. We can start by the cell phone, doing the recycling of cell phone batteries and then we can do it for the laptop batteries, already some amount of work is going on, so we need to scale that. And gradually after we start using our own, we can even get the import, the used batteries and extract material and make the new batteries.

And as long as we can do it with zero waste, it does require some human resources, people power, manpower but India is not short of that, it is a very good industry to set up. What I am pointing out that all three things raw materials we can recycle and get, the battery, cell manufacturing, it is possible to set up as soon as some businessmen see the opportunity, they will do it and it is ready to use or I will say the oil companies ideally set for something like this.

And the battery pack manufacturing which is already going on. So, essentially battery where will we get battery, are you going to import all that battery is well answerable. We will get into details of this also later on once again.