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Technology Enhanced Learning

Video Course on

Electric Vehicles Part 1

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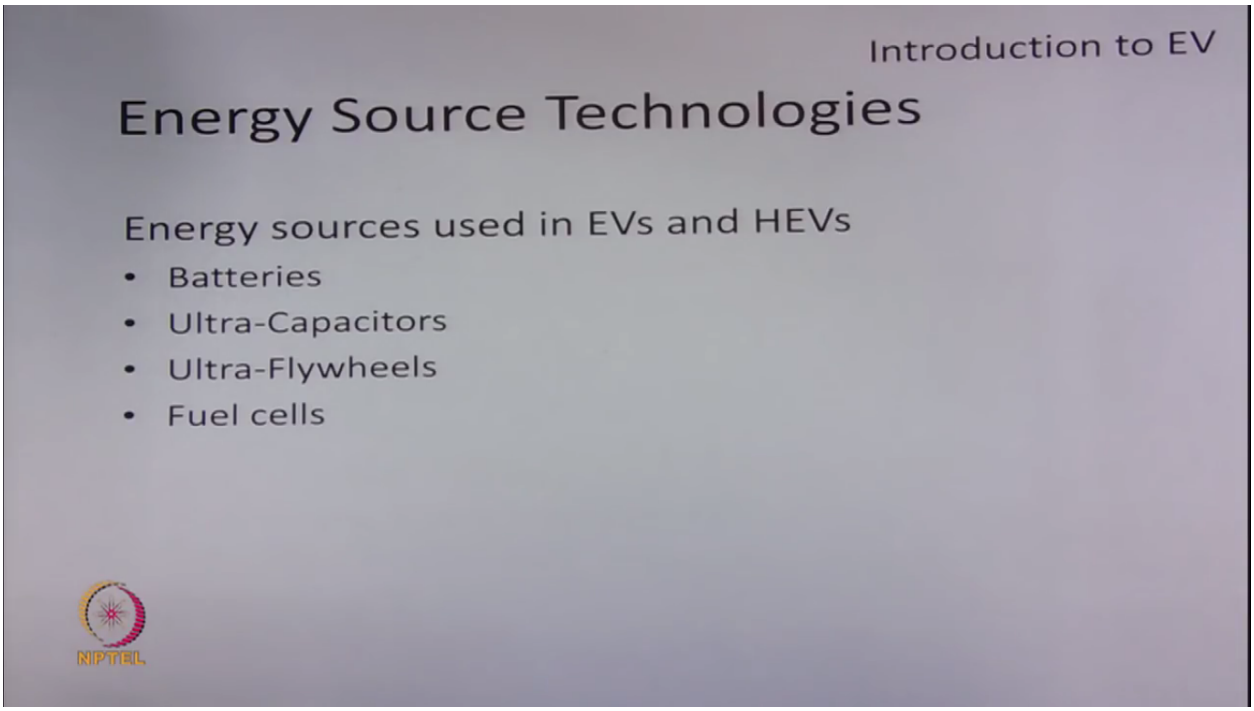
Lecture # 5

Intro EV Energy Source Technologies

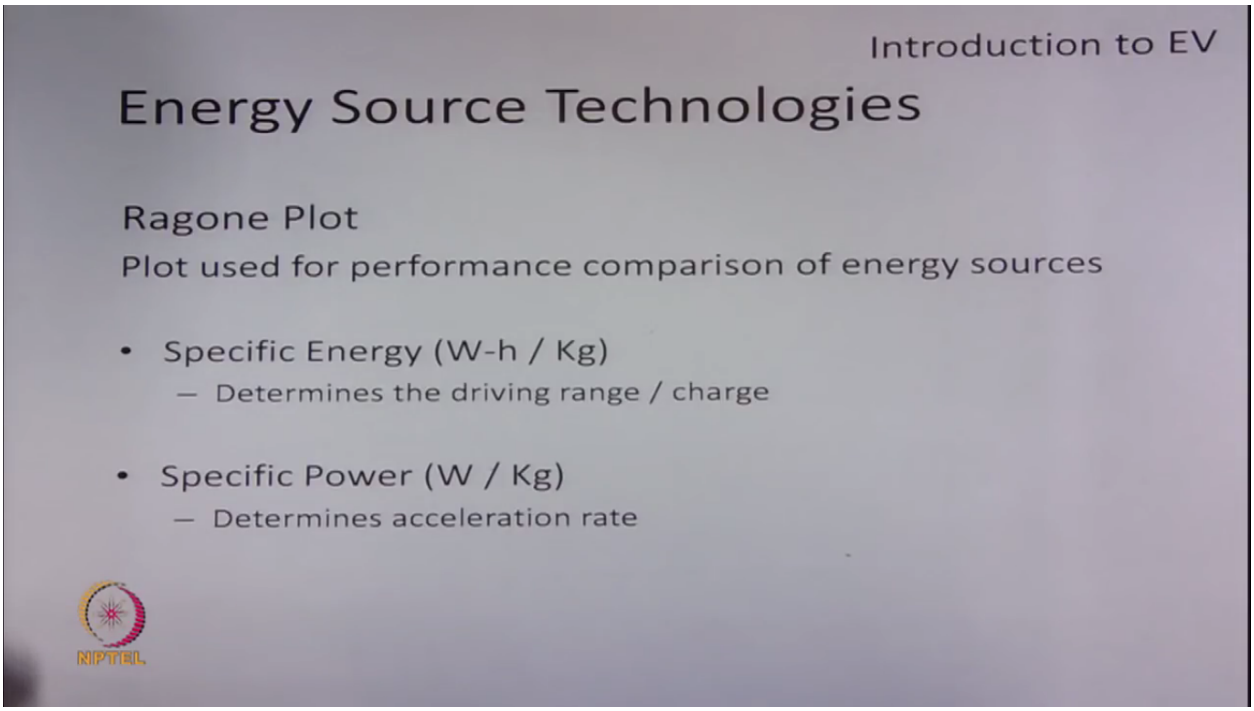
Contents



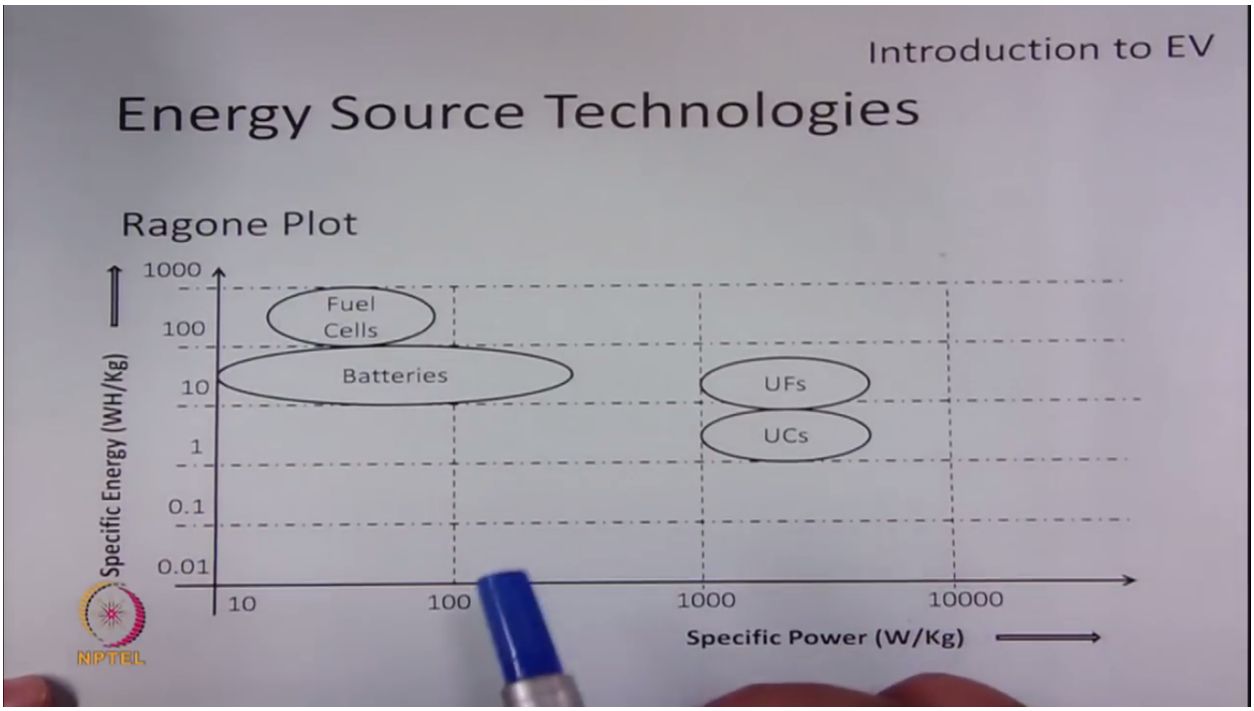
Hello everyone. Welcome to the online MOC course on electric vehicles. So let us begin the next topic under introduction to EV which is energy source technologies. Energy source technology is a core technology in EV since it provides all the onboard energy requirements. There are four main types of energy sources used in EVs and HEVs. They are batteries, ultra-capacitors, ultra-flywheels, and fuel cells.

So battery is a electric chemical device which stores energy in electrical form. On the other hand, ultra-capacitors store the energy in electrostatic form. Essentially ultra-capacitors use very high value of capacitors to store energy. Ultra-flywheels is essentially electrical machine spinning at very high speeds thus storing the energy in kinetic form. Fuel cells uses hydrogen as a fuel and stores the energy in electric form.

While batteries, ultra-capacitors and ultra-flywheel have the capacity of doing bidirectional power flow it can both support charging as well as discharging but fuel cell cannot support charging the energy. Therefore it requires support of batteries to store the energy level during regenerative braking.

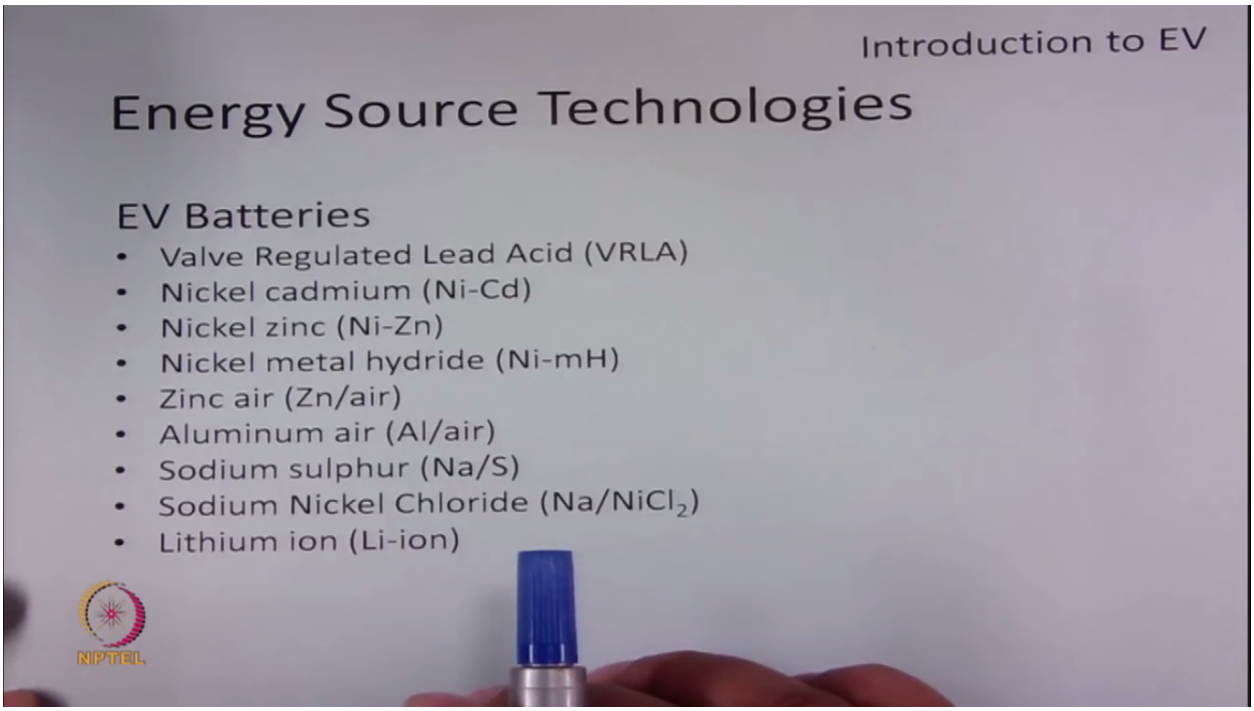


Ragone plot is a popular plot used for comparing the performance of energy sources. So this plot is a chart of specific energy which is a watt hour per kg on X-axis and specific power which is watts per kg on the Y-axis. Why such a graph is very important because the measure of specific energy determines the driving range per charge. So this is directly related to the stored energy in energy source. While the specific power determines the acceleration rate possible in a EV. So a graph which is depicting both the energy and power in the same graph is very useful for designers to select the type of energy source that can be used for a required performance. The specific energy and specific power can be understood analogous to the athlete performance. So specific energy is very similar to marathon running. Therefore it is the deciding factor for range. While the specific power is analogous to the hundred meter sprint race where the acceleration is very important. So in a EV we require very good specific energy and very good specific power. But that is not always possible in energy source. So if we compare the requirement of specific energy and specific power the specific energy is more important since the range is also a very important deciding factor in the selection of EVs.



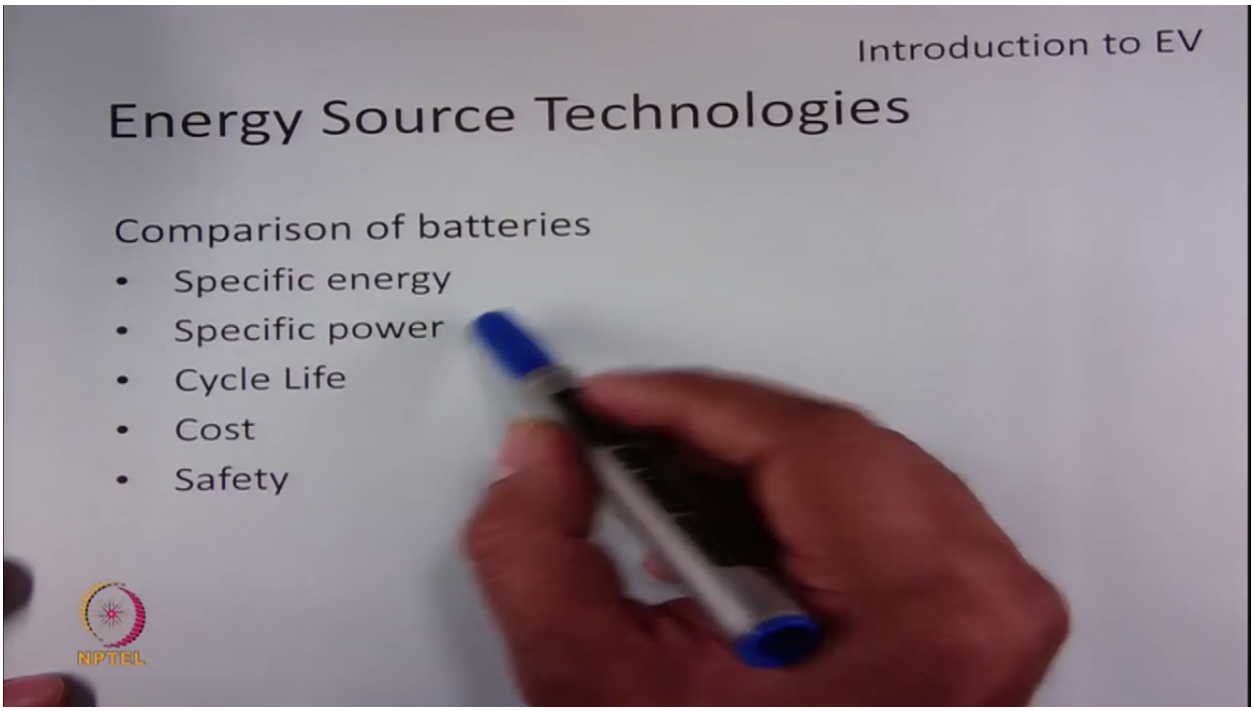
So let us see Ragone plot which is the plot between specific power and specific energy comparing the performance of the energy sources we are discussing. So this is a logarithmic plot so that it can cover all the sources in a single graph. So it can be seen that none of them have both high specific energy and high specific power. So batteries and fuel cell have a relatively higher specific energy while ultra-flywheels and ultra-capacitors have relatively high specific power.

So this energy sources by its own cannot provide high specific energy and high specific power. Therefore there is a trend to use two or multiple of these energy sources together as a hybrid source to meet all the requirements of a designer vehicle. So it can be seen that ultra-capacitors, ultra-flywheels always use batteries as a supporting energy source for providing high specific energy.

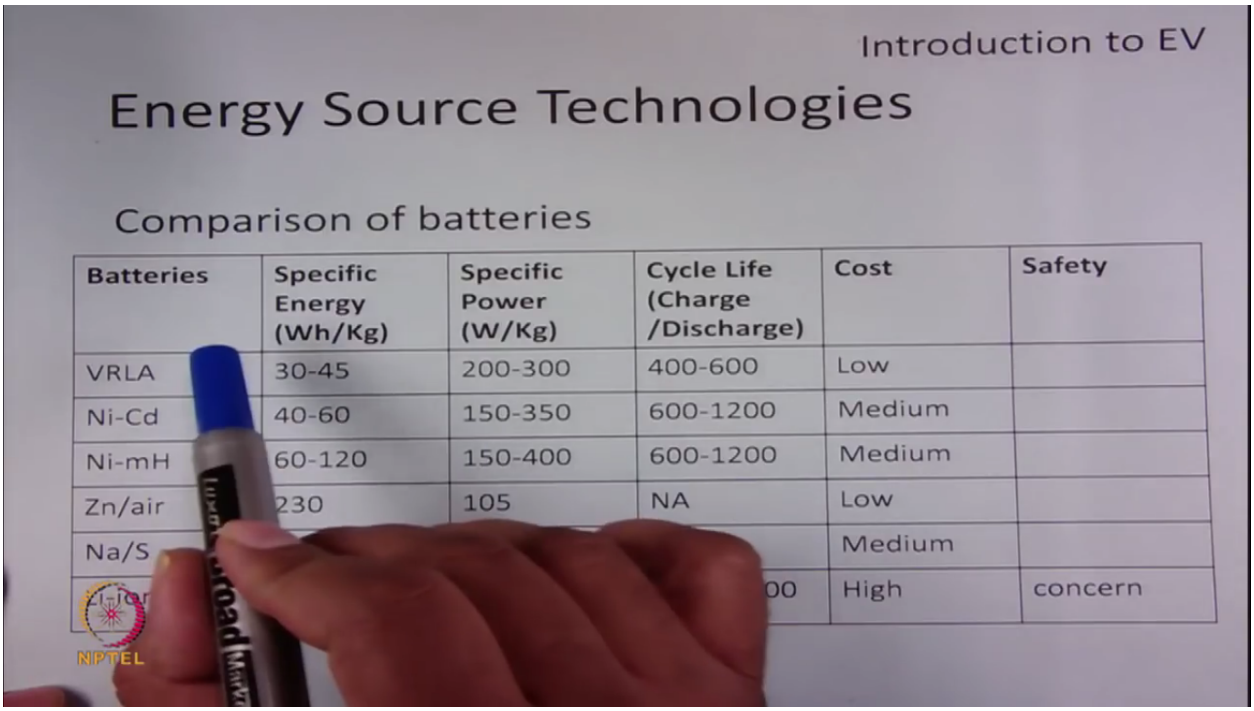


So over the years there's lot of research on battery technology and now we have variety of batteries available with us. So each of these batteries have its own importance. So valve regulated lead acid battery is the most used batteries in EV application because this is a low cost batteries and it's very popular for low end vehicles. On the other hand, nickel based batteries, that is nickel cadmium, nickel, zinc and nickel metal hydride are very popular in the middle segment where reasonably high performance is required. Zinc air and aluminum air are known as mechanical batteries because in these batteries the electrolyte has to be replaced after each discharge. So the electrolyte is zince or or aluminum in this case.

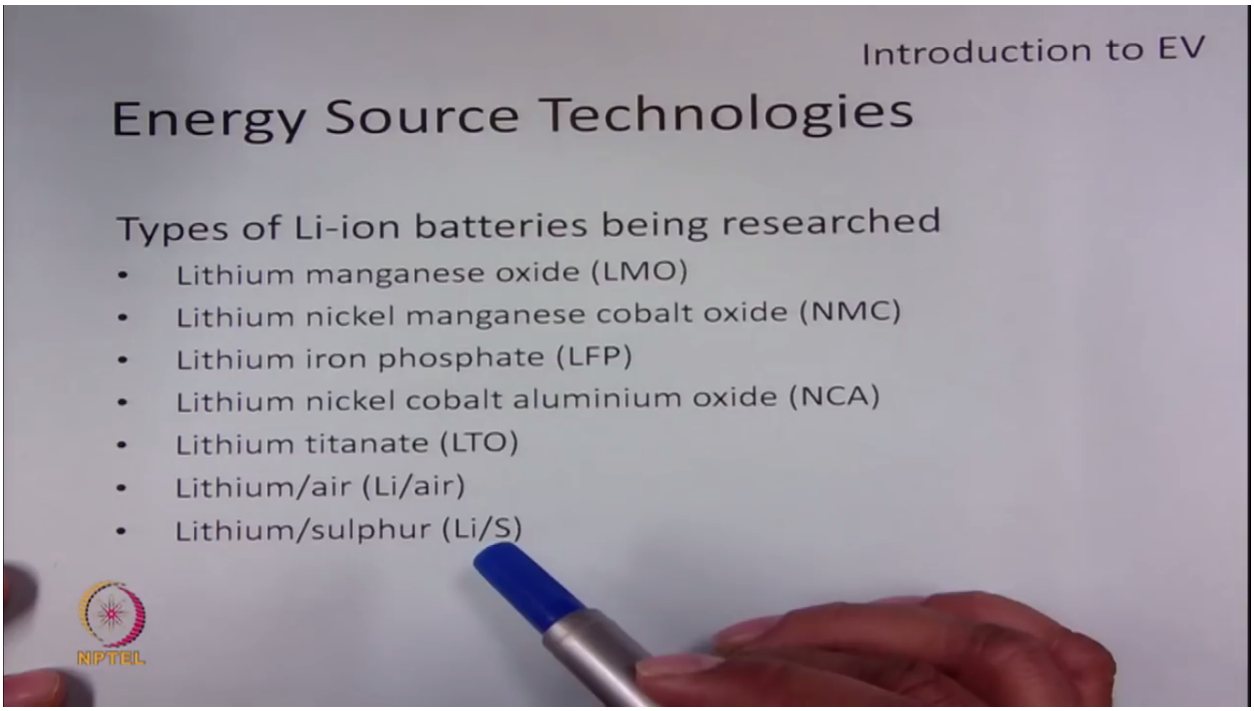
The most popular battery nowadays is lithium ion battery. But this is a costly battery and it is now used only at very high performance and costly EVs.



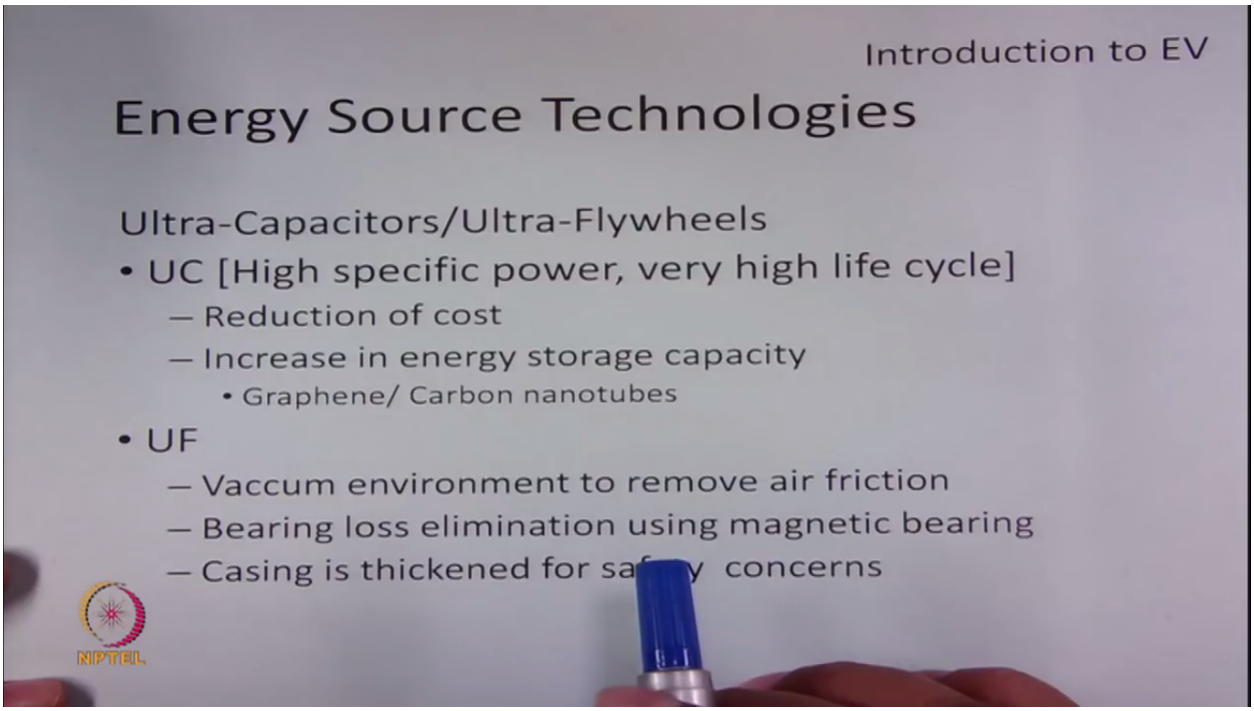
So lot of research is going on lithium ion batteries and it's chemistry such that some of its disadvantage can be removed. So when we compare batteries we not only compare the specific energy and specific power which is very important parameters, we also compare cycle life, cost and safety because to make these batteries as a commercial feasible it is very important that it should be low cost, the cycle life should be higher and safety is the utmost importance because there's always a hazard of explosion or fire if the energy source is not taken care of properly. So this table compares the important battery types which are popular and it also gives the comparison in terms of specific energy, specific power, cycle life, cost and safety.



So we can see that the lead acid battery is reasonably good performance and therefore it is widely used in EVs because of the low cost. While the nickel metal hydride is very famous in medium range vehicles and it provides relatively good performance. If you see the performance of lithium ion battery, we can see that in all this it provides the highest specific energy, specific power, cycle life. So it is the most opted battery for a designer but it's cost is high and it's likely to come down if it is used in mass scale but lithium ion battery also have a concern of safety. If these batteries are not thermally managed properly there's a possibility of fire hazard. So a lithium ion battery pack has to be properly designed to make it commercially viable option.



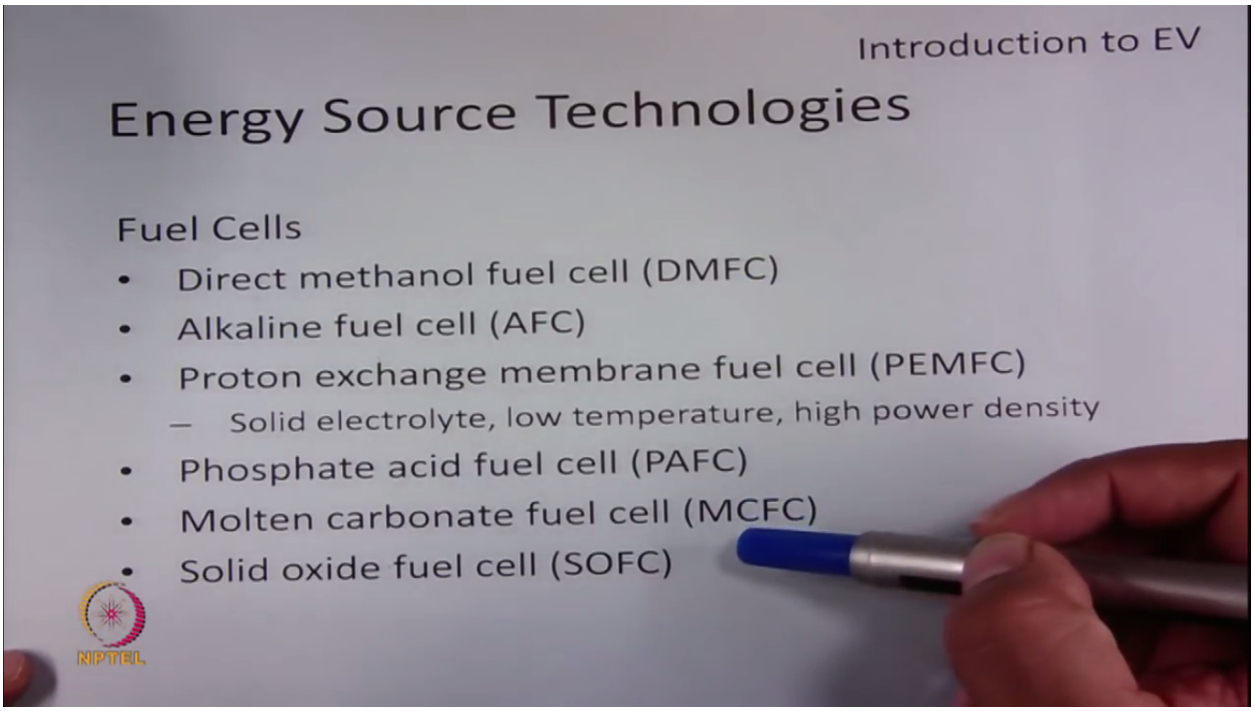
So a lot of research is going on in lithium ion batteries and many types of lithium batteries are under development and under research. So some other famous batteries are LMO which is lithium manganese oxide. NMC which is lithium nickel manganese cobalt oxide and lithium iron phosphate, which is LFP. And currently a lot of research is also going on lithium air and lithium sulphur so that some of the safety concerns can be addressed if these technologies are feasible. So ultra-capacitors and ultra-flywheel as a sole energy source is difficult since it doesn't have the required a specific energy as its performance parameter.



So an ultra-capacitor has high specific power and it typically have a very high lifecycle. On the negative side it is costly so there is a effort to reduce the cost of ultra-capacitor. On the other hand, the energy storage capacity of this ultra-capacitor are researched such that it can be increased. So some new materials such as graphene and carbon nanotubes are promising such that the surface area of this materials can be enhanced which ultimately will increase the energy storage capacity.

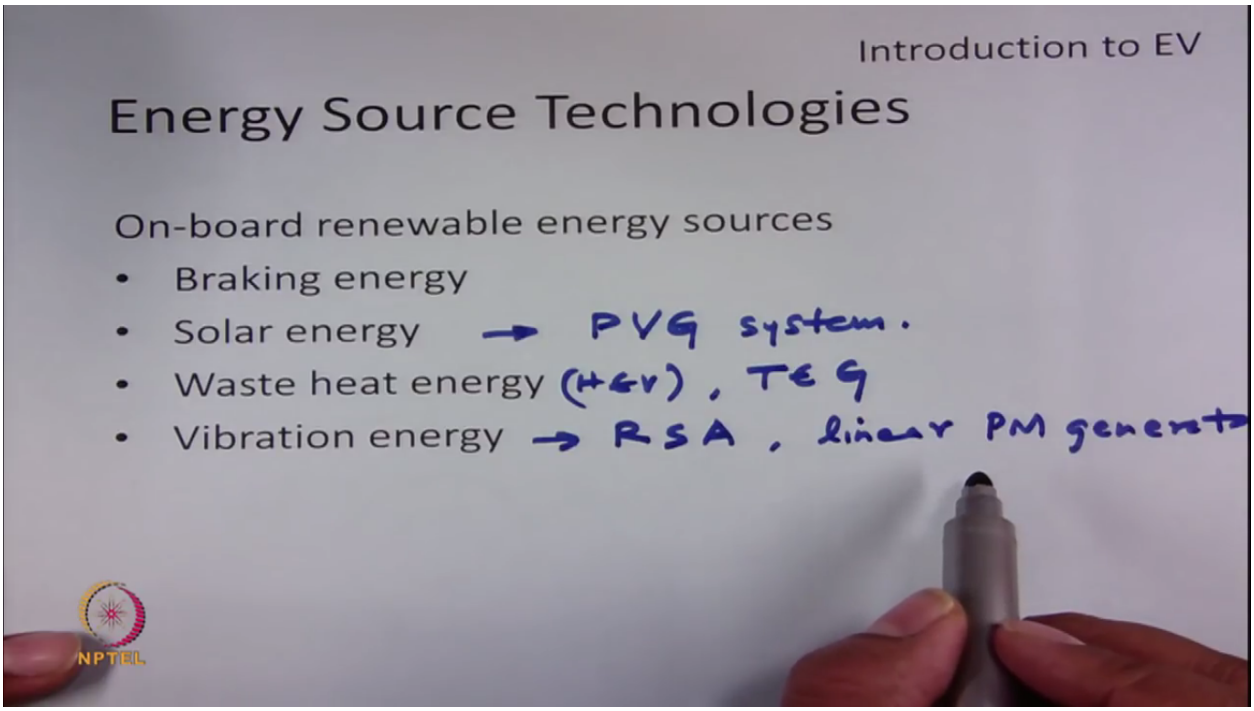
Ultra-flywheel has specific power even greater than ultra-capacitors. But as we know it has a very low specific energy. So there are very efforts to increase its energy storage capacity by finding the means to reduce its losses. So the main loss in a ultra-flywheel is air friction and bearing loss. So there are efforts to create a vacuum environment where this ultra-flywheel can be operated such that it gives a low air friction. The bearing loss can be reduced to a very large extent or eliminated if we use magnetic bearings but that requests a very high end technology and it is costly.

So generally a thick casing is used in ultra-flywheel based batteries so that it can support accidents that occur in ultra-flywheel system. But if you provide a thick casing it increases the weight and it is a drawback in terms of specific energy requirement. So this technology is coming up as a off-board energy source. So a large battery charging station can install a ultra-flywheel and can be used to charge batteries. So in off-board installation the safety concerns are relatively less and it can be very popular in terms of usage.



So a lot of research is also going on in fuel cell technology. So various kinds of fuel cells are popular but the most popular one is PEMFC which is proton exchange membrane fuel cells. So this fuel cell uses a solid electrolyte. It can be operated at low temperature. It provides high power density and efficiency and it can be quickly started up. So this – all these features make this fuel cell as a very popular one.

Now all the disadvantage is that it uses platinum as one of the electro catalyst. So platinum is a noble metal and it is always advised not to use it much because of its cost. So another fuel cell is becoming very popular which is solid oxide fuel cell. So this fuel cell doesn't use platinum, but it has a disadvantage of high temperature operation. So this is still under research and so other than the energy source we discussed, there is also a lot of attempt to look for energy sources which can be used on board to generate energy within electric vehicle.

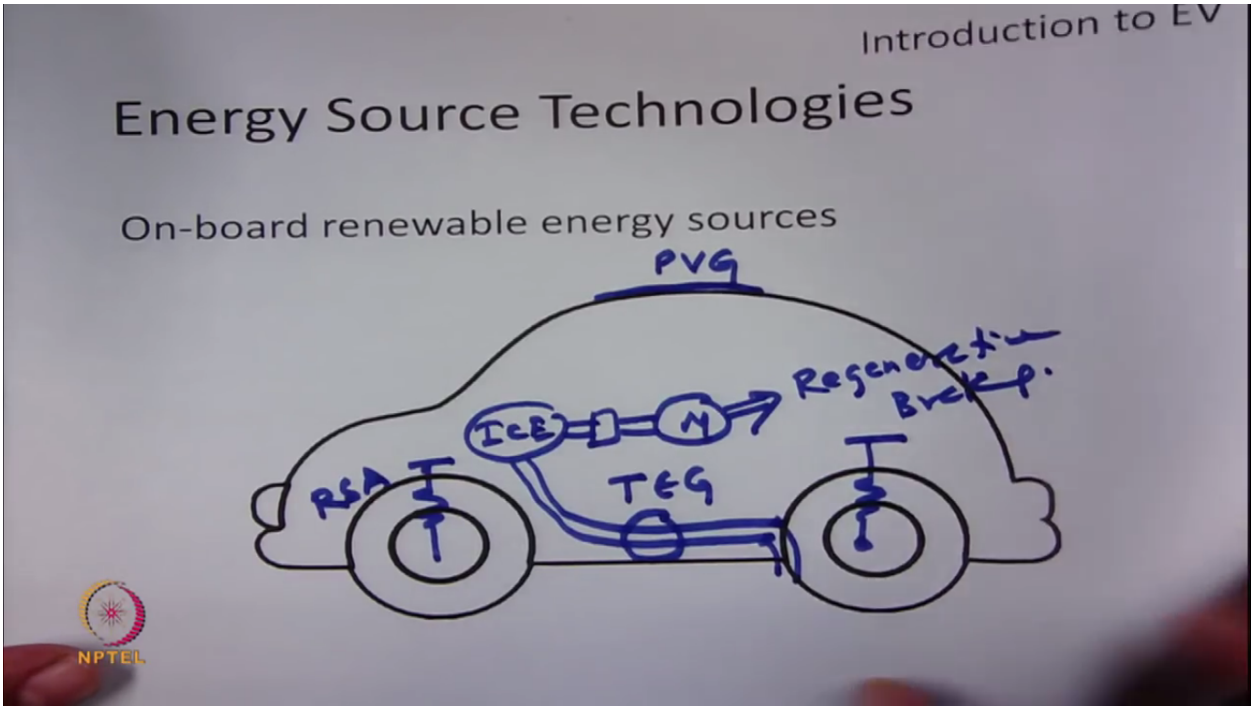


So we are all aware of braking energy. This energy is the energy we obtain when the vehicle is running downhill or when it is applying breaks. So this energy can be harnessed by operating the motor as generator. But there is a requirement from the controller side which has to be handled properly. So when the regenerative braking is happening, the system has to coordinate with a drivers pedal operation such that the safe braking can be ensured. So we all know that solar energy is one of the options we can explore if we install PV cells on the roof of EV. A very successful example of this kind of harnessing solar energy is known to us in terms of solar plane which is known as solar impulse, which has shown a lot of promise in terms of harnessing solar energy. So an EV can install PV cells on its roof. So this kind of generating system is known as photovoltaic generation system. So it observe the solar iridescence which is available during daytime and can be used to charge the battery.

Since the surface area of a car is limited the amount of energy that can be recovered can be few hundred watts per day. So waste heat energy extraction is possible in HEV where we use an IC engine in addition to electric motor. So IC engine dissipate a high amount of energy as heat. So this heat is generally thrown out by exhaust outlets. To harness this kind of energy a thermo-electric generator can be installed between the IC engine and the exhaust outlet which can harness this energy. Typically few hundreds of watt can be recovered per day using this technology. Since both the solar Irradiance and the heat is a nonlinear phenomena the power electronic associated with this typically use MPPT techniques which is maximum power point technique so that maximum energy can be extracted.

We all know that an electric vehicle or any vehicle for that case undergoes lot of vibrations due to road roughness or vehicle dynamics. Therefore to support comfort to the rider and safety shock absorbers are used in these vehicles. It is also possible to use this energy and convert it to electricity and charge the battery.

So device known as regenerative sock absorbers are used which not only support damping off vibrations, it also supports converting that energy into electrical form and not wasting as heat energy. So this device is a typical electromagnetic generators which harness energy in electrical form. So there is a lot of research going on in this area and linear PM generators are used such that not only it can provide a smaller size, but it can be also very efficient in terms of power extraction.



So if we see the location of these devices, so typical PVG will be installed here. The RSA will be installed on the top of all wheels. In HEV the IC engine so here a TEG will be installed so that it absorb the heat energy dissipated from the IC engine before it is out from the exhaust. And when we all know that if it's coupled to the motor this can be used for regenerative braking.

So that is all under the topic energy source technologies. In our next interaction we will discuss about battery charging technologies. So thank you for listening.