Hello everyone, welcome to the online course on electric vehicles. Let us discuss the next topic under introduction to EV, which is vehicle to grid technologies. So vehicle to grid technology is a emerging technology. It comprises of gridable EVs, the EVs which can be connected to grid, utility of power system, and information technology. So we all know that electric vehicles use batteries for registry systems, therefore because of the availabilities of batteries and if that EV is capable of connecting to grid, it is possible to use those batteries as power generators and it is possible to interchange energy between the battery and the grid or grid to the battery while charging. Therefore this technology enables integration of energy flow and the information flow such that both the EV owners and the power grid or the power system gets benefited.

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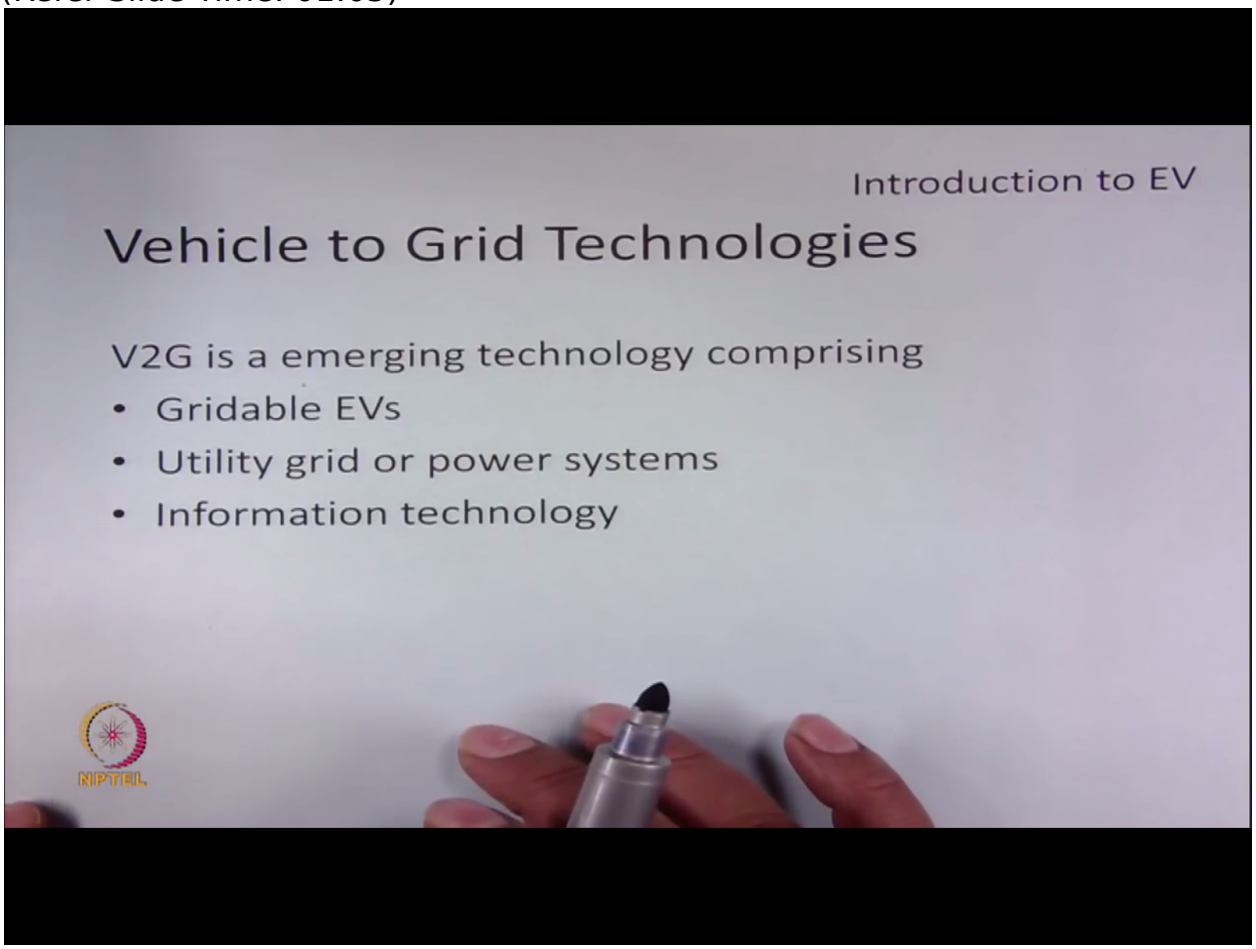

So what are this credible EVs. So EVs which can be connected to grid are known as gridable EVs. So in hybrid electric vehicle PHEV and REV are gridable, means they can be connected to grid for charging the battery. They can be also charged using petrol or diesel from a filling station. A BEV always charges the battery from grid, but it is also possible to connect this two systems such that they can enable the power flow from the vehicle to

the grid. So this system requires the capability to transfer energy both from the grid to vehicle and from vehicle to grid.
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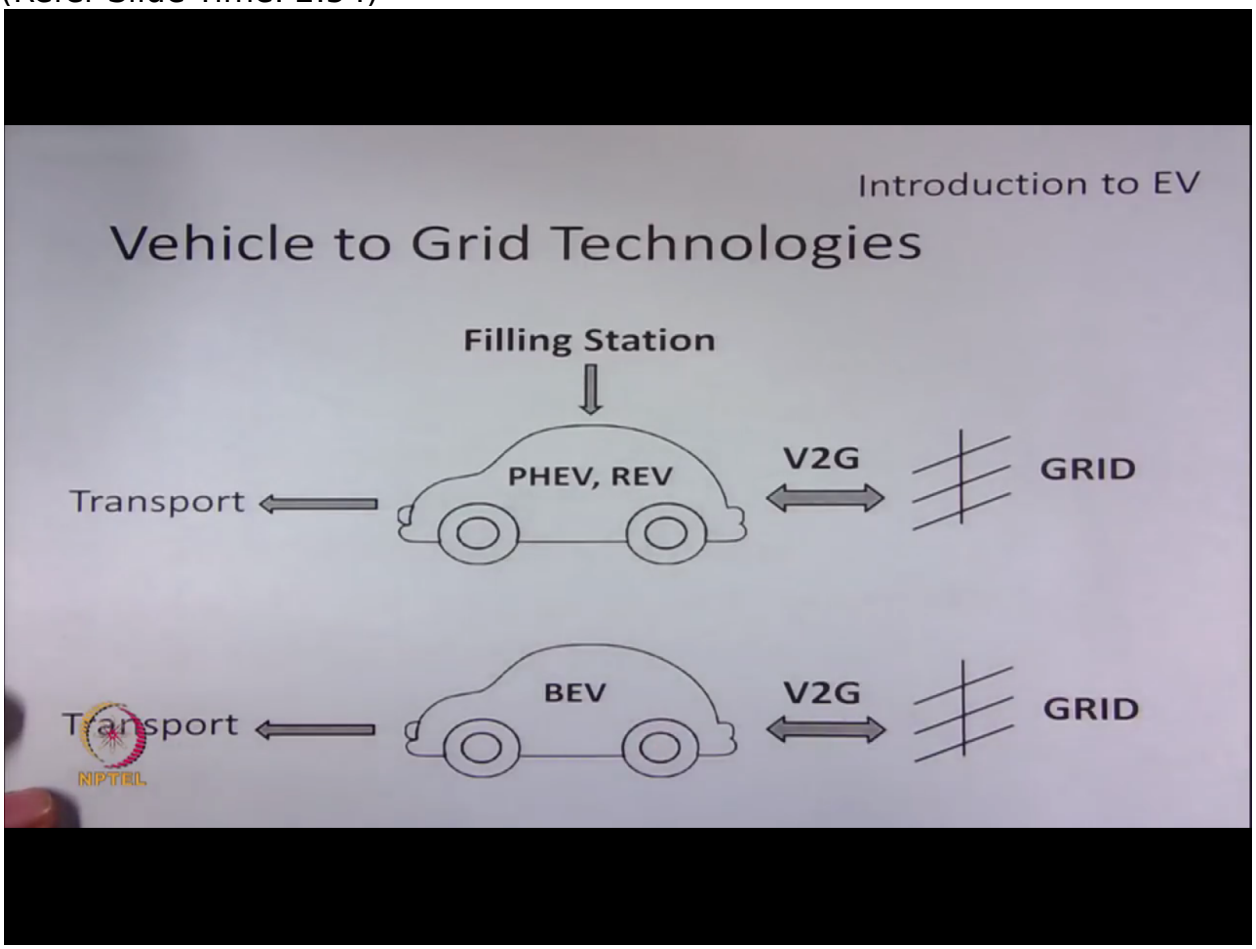

So we can also see this V to G as a emerging new business model. So what it requires, it requires communication of EVs with the grid operators such that not only we can control the energy flow from the battery to the grid, we can also control the charging rate of the batteries. We all know that any vehicle or electric vehicle for that are unused for 90% of the time, so it will be remaining ideal in a parking area. So if we can see that all these batteries, if they are connected to grid, while they are parked, and with the estimate that each EV can typically store anything between 4 KW hour to 80 KW hour, we can see that if they occupy you know large section of the total vehicles on the road, let's say typically 20 to 40% penetration is there in the vehicle segment. It can create its own autonomous power storage as well as power generator capacity. So this is... the coordination of this can be a new business, and is a new opportunity, and a new technology, which is under development. But now the system also has to take care of the power system dynamics and stability. So if you bring a new generator whose dynamics is different from the present grid, we have to start study such that it understands the effect of these systems to the present utility grid.

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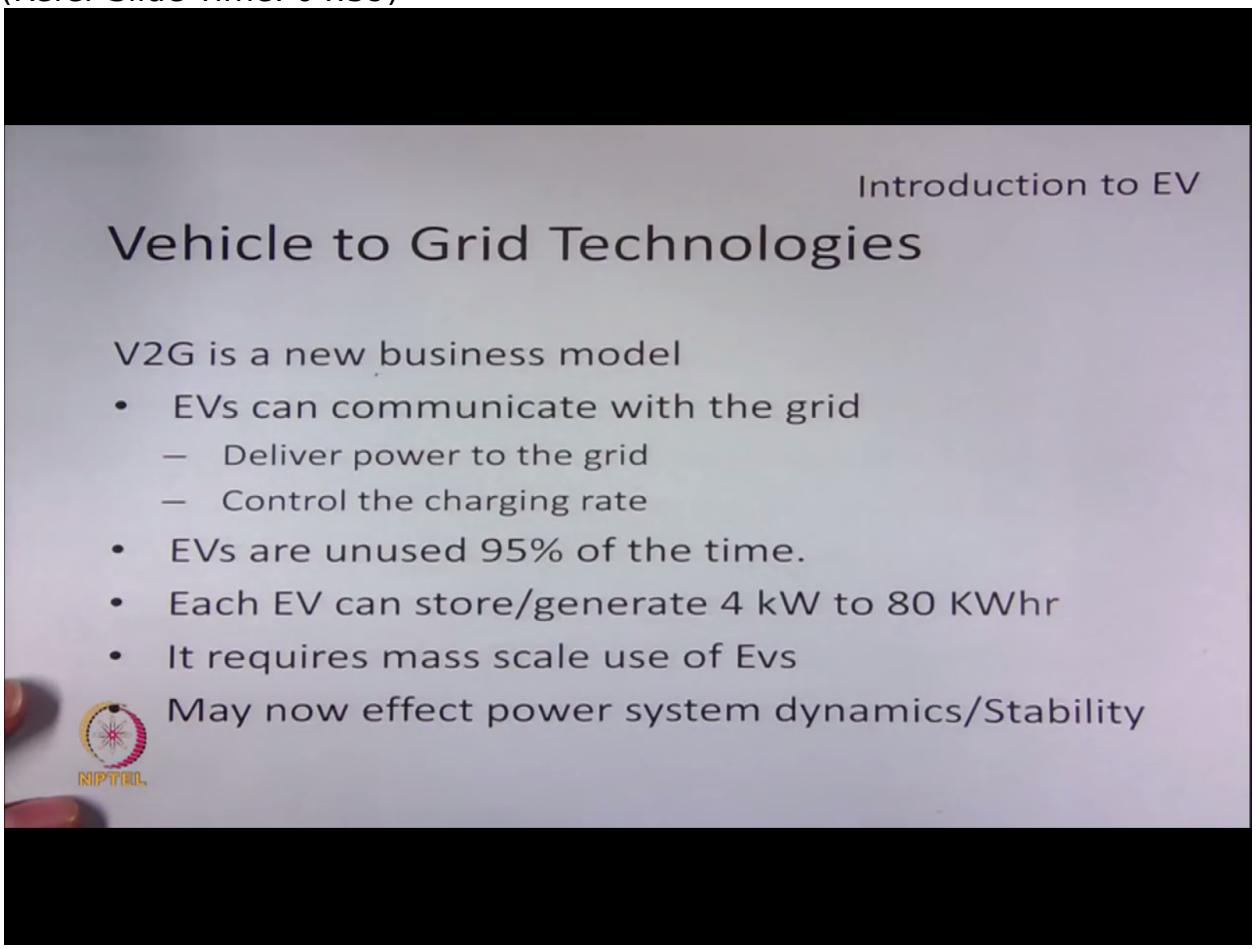

So as mentioned earlier, if individual EVs do the V2 action and try to connect to the grid, it will be very ineffective, because EV can have maximum power of 85 KW, but that is always on the high-end models, but typically this averages between 10 to 15 KW. So if we operate such a system, it will be very ineffective and inefficient. So it is always advised to create a pool of EVs and make a common power aggregator, means the agency which can plug this pool of EVs and present a total system as a one system to the grid. It that way it will be meaningful and it will be very efficient. So the power aggregator has to take care of internal energy flow such that it minimize the power demand and losses. Means, some of the vehicles may like to charge slowly, some EVs may like to charge using fast charging, but there may be many vehicles who are ready to generate power to the grid. So the power aggregator should understand the requirement of the pool of EVs, such that it understands the typical power demand, which needs to be supported from the grid or it can generate to the grid, such that the losses are minim mum or efficiency is maximum. So it should enable the talk between vehicle to vehicle, vehicle to building, if it's a large building and it can store, you know, 200 or 300 vehicles in the parking area, or vehicle to home, if many homes in the area are connected to a common aggregator. It should enable all

these operations such that the efficiency of energy transfer is maximum. On the other hand this power aggregator now has to see that at the point of common coupling to the utility grid, it should optimize the voltage deviations, because since it's a bigger energy source, it can affect the voltage of the grid. So it should see that it optimizes the voltage deviation and the point of common coupling. It should try to maintain the TST requirements of the utility grid and it should do all the analysis and estimates such that the efficiency is maximum and the profit to the both EV owners and the grid agencies are maximum.
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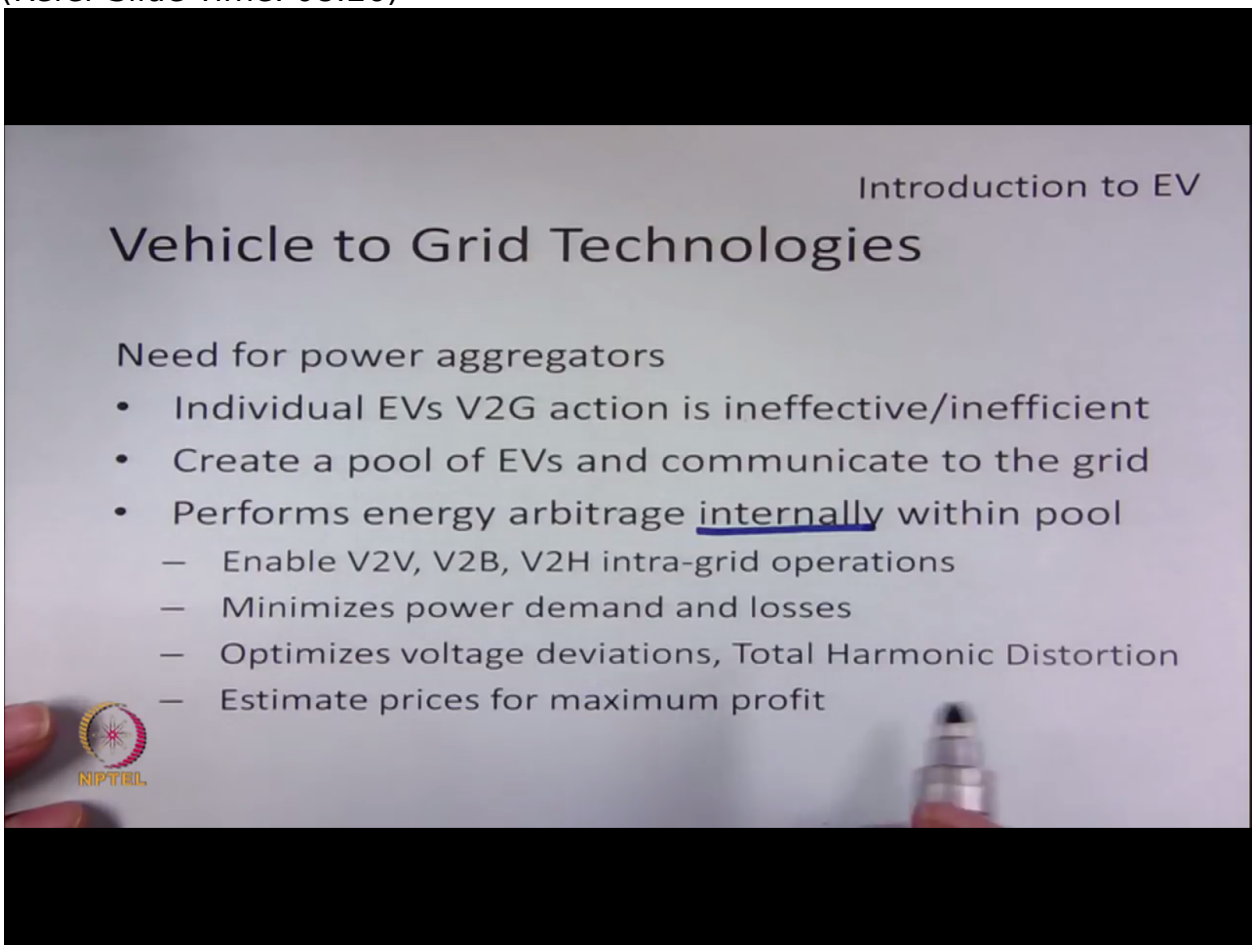

So this is a simple model which can tell the different operations, which can go under a V2G operation. So you can see that, if there are many homes, which are isolated, but located nearby in a locality, they can be connected to a common aggregator. So there will be energy transfer between vehicle and homes, actually bidirectional and there can be talk between vehicle to vehicle, if they are nearby. So aggregator will see the dynamics and the energy flow within these pool of homes and vehicles. It is also possible to have the similar thing when we have a common building, now a days in urban areas, very big buildings are constructed with two and three basements for parking, so it has high pool of vehicles located or parked in

the basement. So similar thing can be also done in the parkings. So this all will be connected to a common aggregator and it will talk to grid. So these are basically the scheme or the scheme center, which V2G operation can be implemented.

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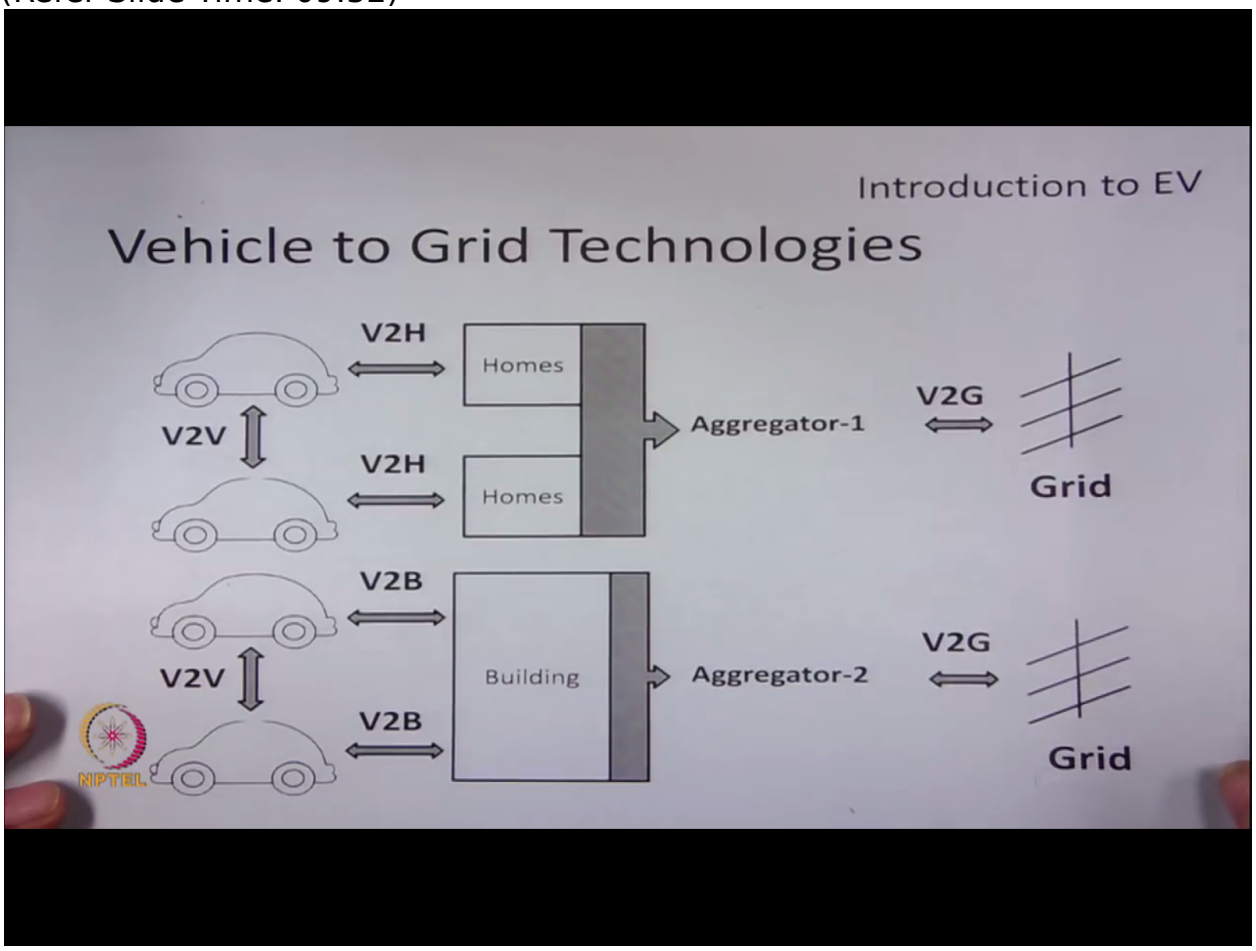

In addition to that V2G technology has lot of applications to power systems. So now if we have lot of aggregators connected to grid, if we say power generator system, which is capable of taking energy, capable of storing energy, and capable of delivering energy. So if such a system is connected to power systems, it can support power system in many ways. So we all know the power generation always try to match the load demand, but there will be lot of fluctuations between the peak hours during the day and the off peak hours during the night. So the V2G operation can help the grid by charging under coordination during off peak hours, during night and it can support the grid by energy generation during day time to support the peak load demand, or it is called peak shaving. It can also support regulation of the grid voltage. Spinning reserve, so basically these are the systems connected to the grid, which are dormant and they are started only during peak load demand. So typically these are standby generators or diesel generators, which are started, when there is a peak demand. So we all

know, the installation of a such a system is expensive and as you know, very inefficient, and also basically it takes lot of time to startup for the mechanical systems. So if EVs under V2G application can support this by quickly supporting the peak demand in a very high dynamic fashion. Secondly, it will not be a additional burden on the power system and it will be correspondingly less expensive. The motor starting and reactive revolution are some of the areas, which is also supported by synchronous condensers and such kind of things in power grid. So this demands lot of reactive power. So we all know that if we use a power converter in this applications, it typically have a electrolytic capacitor in the DC link. So this DC link capacitor is a reactive source of energy. So it is possible to use the reactive power capability of all these EVs and can help the grid to support reactive power compensation. We all know that lot of renewable power is getting added to the grid, like wind and solar, but these sources of energy are intermittent in nature. It depends on solar irradiance or the wind availability. So there also this V2G and the support of EVs can be utilized such that these transients can be supported in a high dynamic fashion.

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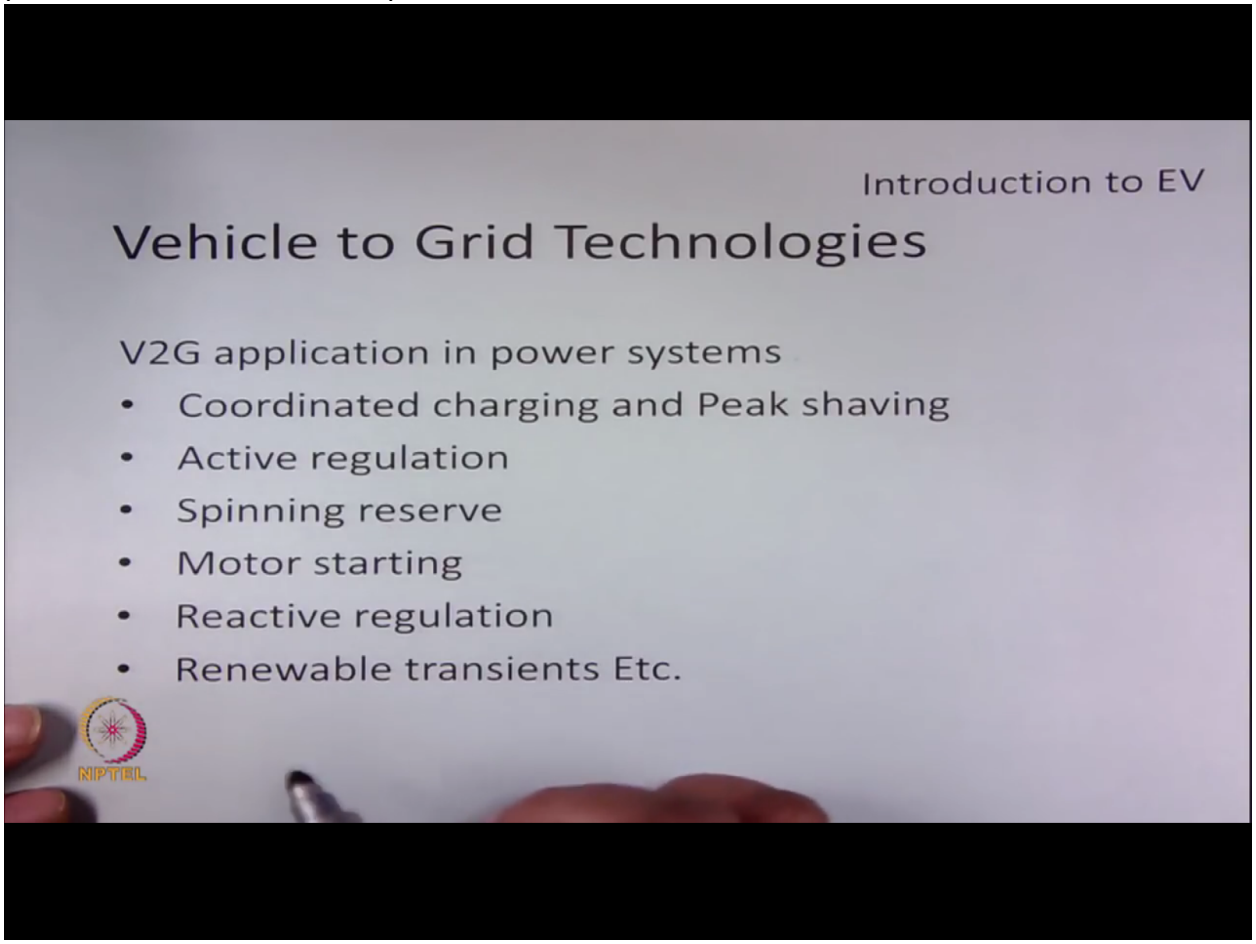

So let us see how this peak shaving and coordinated charging is done in a V2G technology. So if we plot a 24-hour time in X axis and a load profile of a

typical power system in a Y axis, we will see that if we start from midnight to... and take 24 hours, we can see that, so the power demand will be typically like this. So this is basically the unutilized portion of the power system capability and this is the additional requirement during the afternoon period of the day. So this will be generally taken care by standby generators. Now the EVs can play a major role and it can support, you know, a coordinated charging during night or off peak period, and it can support peak shaving or support during peak load demand.

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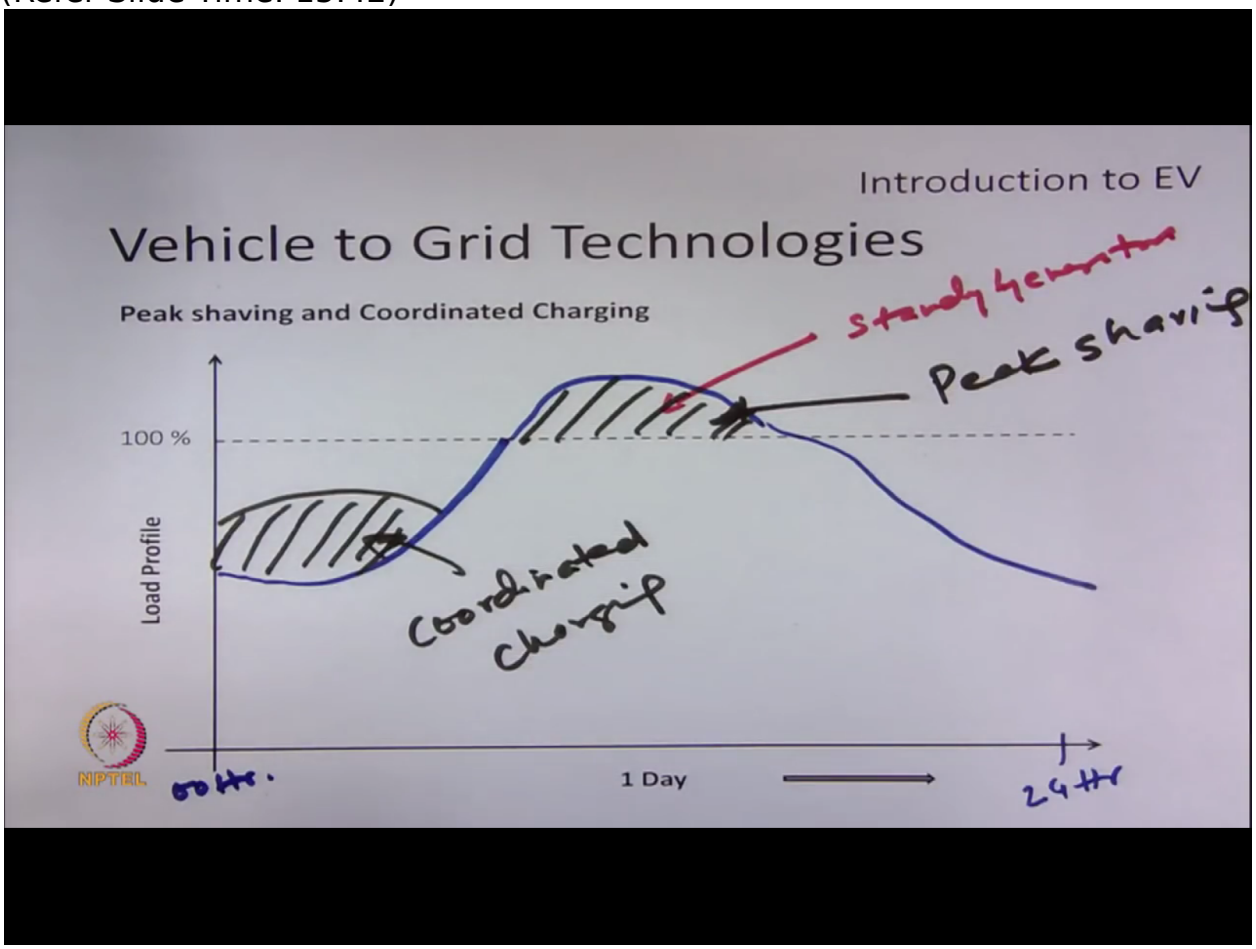

So if we see the power converter that is required in a V2G operation, generally we have a battery bank and we have basically power converter for, which is connected to basically motor operation, and we use... so we have basically a source of energy, let's say three phase, so we generally connect a diode rectifier, if we only want to use the charging capability, but in these case we may require to use a bidirectional power converter, so we may need another power converter, which can support the energy flow from battery to the grid as well. And we also know that a DC link also has electrolytic capacitors, so this can be used to support, reactive power support to the grid. So this can act as a shunt to the grid and it can enable in maintaining the TST of the grid and also support reactive power compensation required

during voltage regulation and motor starting. So this is called basically grid side converter.
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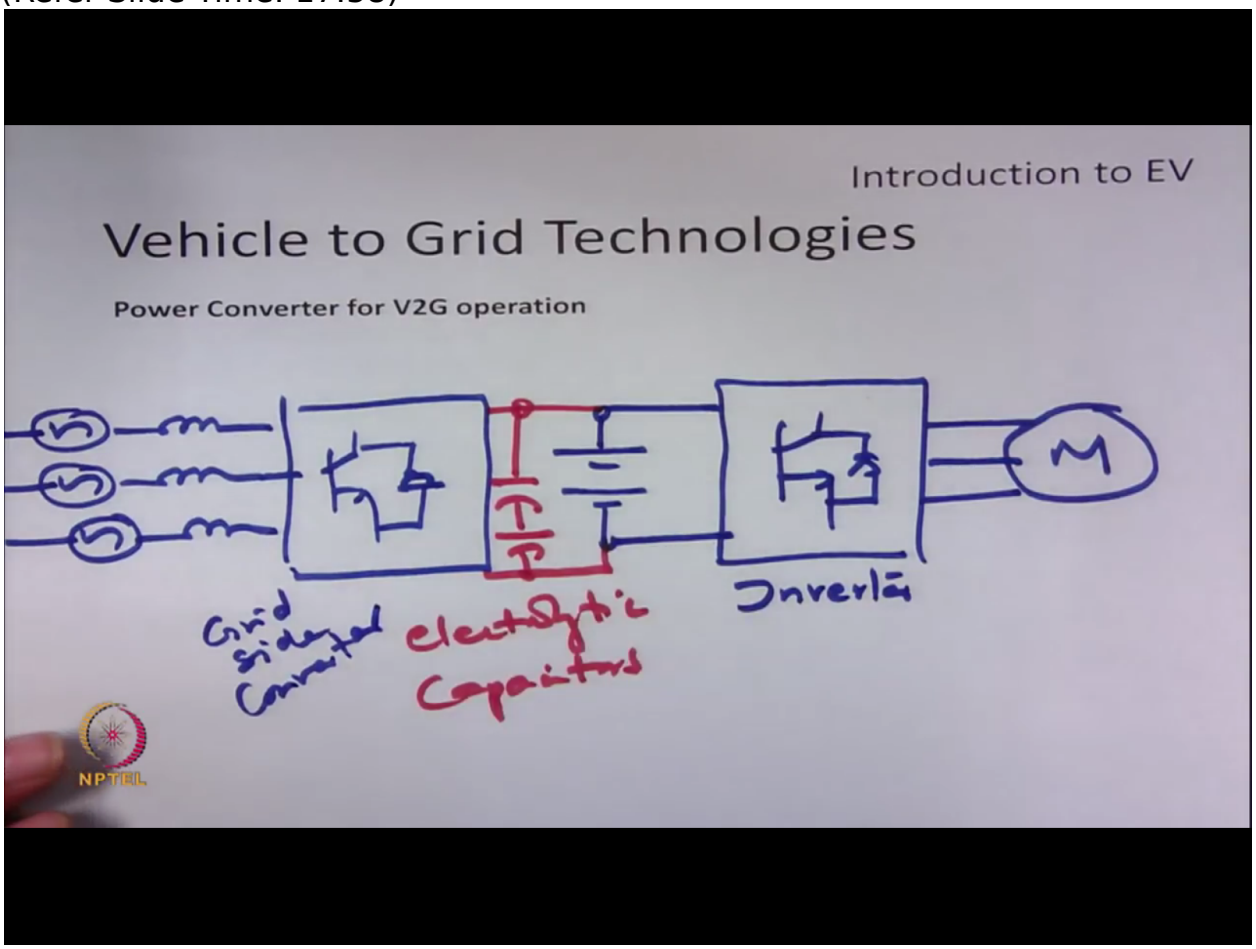

So that's all under vehicle to grid technologies. We will see that in detail, probably later. So in our next interaction, we will cover the types of EV systems and the subsystems and their configuration in our next interaction. So thank you for listening.
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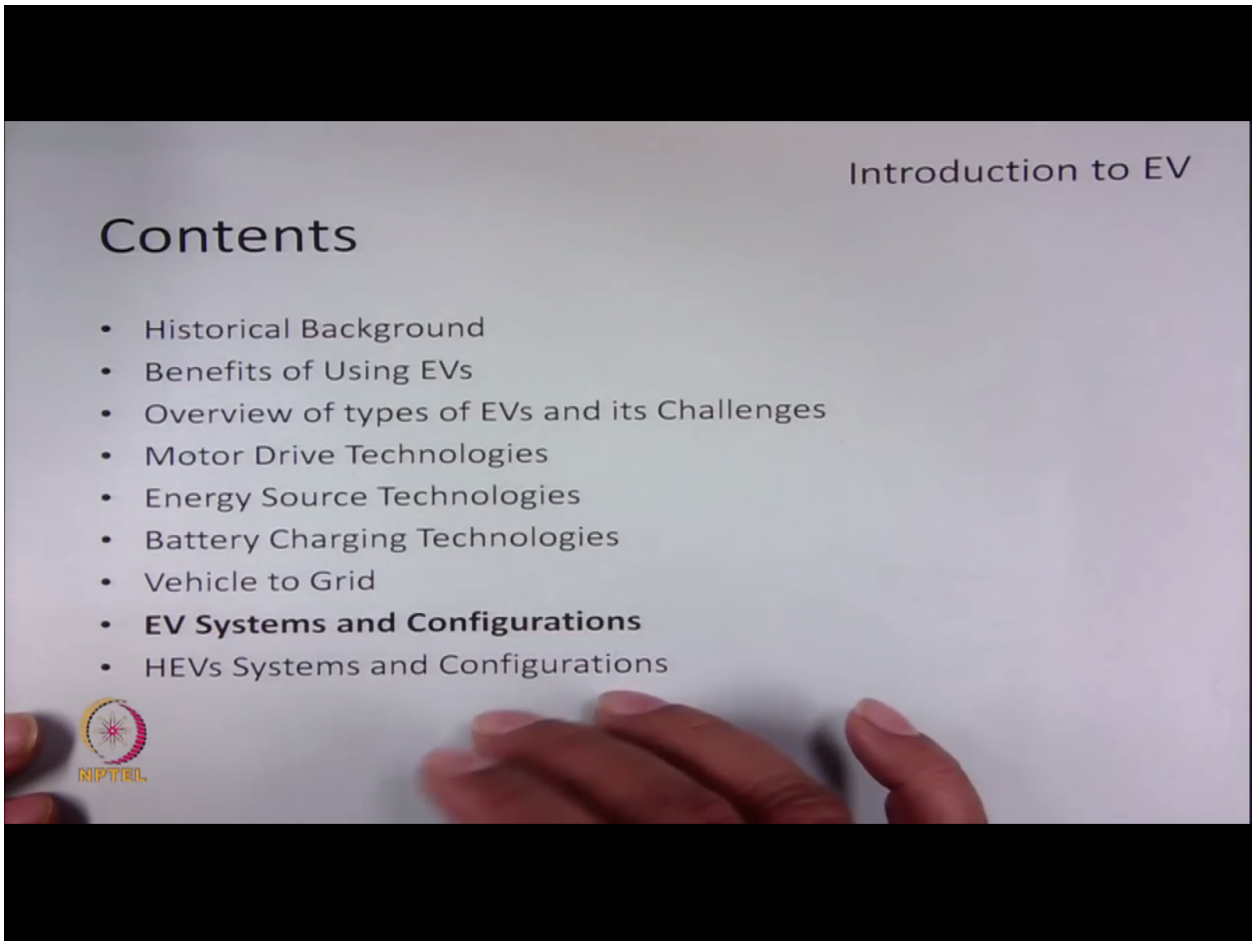
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