

**Module 01**

**Lecture #1**

**Intro EV Historical Background**

**Electric Vehicles – Part-1**

Hello, everyone. Welcome to the NPTEL online course on Electric Vehicles.

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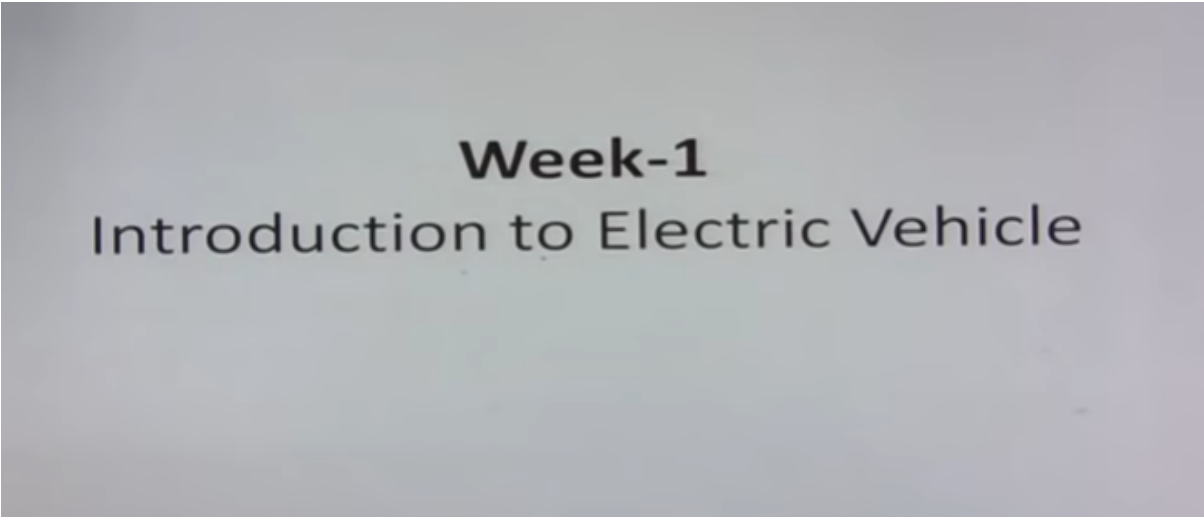
# Contents of the course

Introduction to Electric Vehicle

Vehicle Dynamics: Modeling and Simulation

So the contents of this course are;

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**Week-1**  
Introduction to Electric Vehicle

So let us start, the topic of Week-1, which is Introduction to Electric Vehicle.

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## Contents

- Historical Background
- Benefits of Using EVs
- Overview of types of EVs and its Challenges
- Motor Drive Technologies
- Energy Source Technologies
- Battery Charging Technologies
- Vehicle to Grid
- EV Systems and Configurations
- HEVs Systems and Configurations

So content of this first topic are the following; we start with historical background. Then we will discuss, the benefits of using EVs, compared to other modes of transport; overview of different types of EVs and their challenges; Motor Drive Technologies; Energy Source Technologies; Battery Charging Technologies; Vehicle to Grid; Different Types of EV Sub systems and their Configurations and Different types of HEVs sub systems and their Configurations.

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## Historical Background: Phase-1

- In 1834, the first non-rechargeable battery operated EV (tricycle) was built by Thomas Davenport.
- After invention of lead-acid battery, a rechargeable battery based EV was built by David Salomons in 1874.
- Twelve years later, first electric trolley systems was built by Frank Sprague in 1886.
- In 1900, among 4200 automobiles sold in USA, 38% were EV, 22% were ICEV and 40% Steam powered vehicles.

It is very interesting to know that, the first EV was built in 1834, which is about, 150 years back. It was built on a non-rechargeable battery that was available at that time. After the invention of lead-acid battery, recharge, a rechargeable battery based EV was possible and was built in 1874, by, David Salomons. With this development, it was possible to develop commercial products, by 1886. So all this developments, led to, popularisation of EVs, in the manage team automobiles, in a global

scenario. So it can be seen that, in 1900, among 4200 automobiles that were sold in USA, 38% were EVs.

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Introduction to EV

## Historical Background: Phase-1

- Several companies in US, England and France made EVs by 1900.
- Electric Carriage and Wagon Company, US [1894] 'Electrobat'
- Pope manufacturing Company, US [500 EVs by 1898] 'Columbia'
- Riker Electric Motor Company, US 'Victoria' [1897]
- London Electric Cab Company, England [started 1897].
- Bouquet, Garcin and Schivre (BGS), France [1899-1906].
  - BGS EVs in 1900 had world record of 290 Km/charge.
- An EV named 'Jamais Contente' captured a record of 110 Km/Hr in May, 1899. *(never Satisfied)*

By 1912, nearly 34,000 EVs were registered in US.

So several companies in US, England and France, made EVs by 1900. And some of the popular companies are, Electric Carriage and Wagon Company, which came up with its model called, 'Electrobat', in 1894. Similarly, there was a model called, 'Victoria', in 1897, which, has become a hosal name, in 1900. Since it had a very good design. This company called, 'BGS', in France, which has developed, many types of EVs, in all skills. Right from cars', buses' and limousines' of all varieties. So one of its products, had world record of, 290 kilometres, per charge. There was another EV, named, 'Jamais Contente', which has captured a record of, 110 kilometres, per hour in, 1899. Apparently, the meaning of this word is, never satisfied. So we can see that, by 1912, around 34,000 EVs, were registered in US. So it was one of the bainstream modes of transport, during that time.

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Introduction to EV

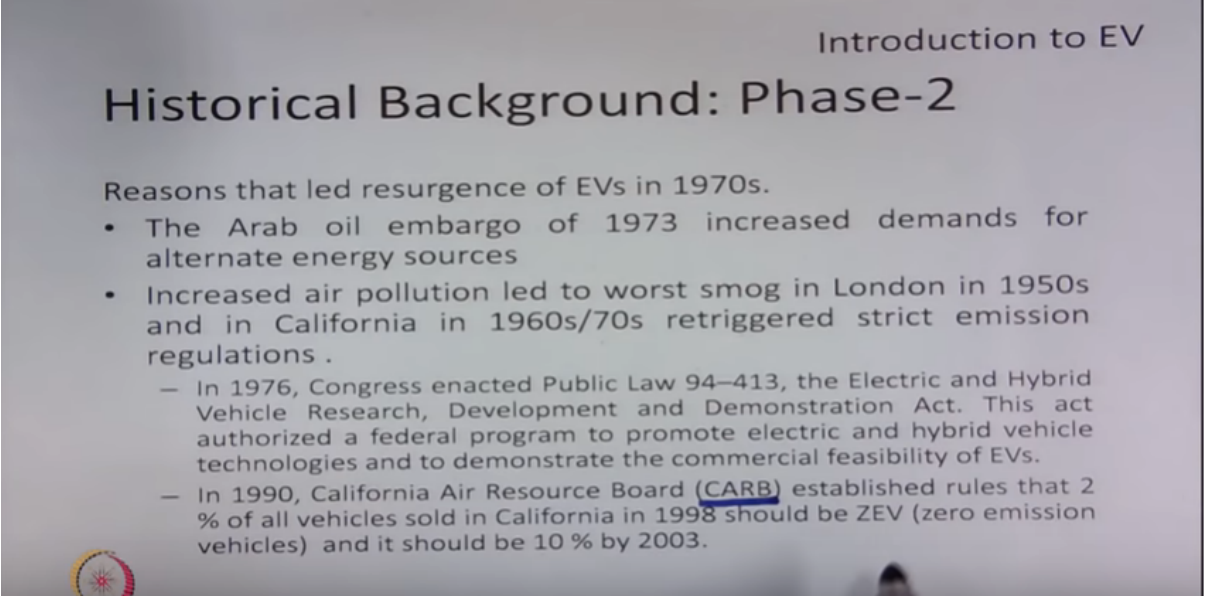
## Historical Background: Phase-1

EVs disappeared by 1930s.

- First Development was that, Henry Ford mass produced 'Ford Model T' in 1925, and reduced its price by over 1/3<sup>rd</sup> to its price in 1909.
  - This made EVs costlier compared to ICEV.
- The second development was invention of automobile starter motor, by Charles Keetering, that helped remove manual cranking required in ICEV, and enabled electric ignition and start.
  - This made ICEV user friendlily compared to EVs.

But unfortunately, EVs started disappearing by 1930's. There were two developments, which led to this happening. First development was, that, Henry Ford, has gone for mass production of, 'Ford, Model T', in 1925. And was able to reduce the price of it, by over one third of its, conventional price, at 1909. So due to this, the EV become much costlier, compared to ICEV engine based cars. Another development, which supported the first development, was the invention of Automobile Starter motor. Incidentally, the IC engines that time were unable to start on its own and need manual cranking. So this automobile starter motor, were able to start and provide electrical ignition to the IC engines. Which is a big milestone, in the development of, IC engine based, vehicles. So due to this two developments, not only the cost of IC engines, based cars were less, also it is very user friendly, compared to, compared to EVs and Customer satisfaction. Because IC engine can be used now in Urban areas and Remote areas. And it doesn't require electricity, to charge the batteries, required in a, conventional EV.

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Introduction to EV

## Historical Background: Phase-2

Reasons that led resurgence of EVs in 1970s.

- The Arab oil embargo of 1973 increased demands for alternate energy sources
- Increased air pollution led to worst smog in London in 1950s and in California in 1960s/70s retriggered strict emission regulations .
  - In 1976, Congress enacted Public Law 94–413, the Electric and Hybrid Vehicle Research, Development and Demonstration Act. This act authorized a federal program to promote electric and hybrid vehicle technologies and to demonstrate the commercial feasibility of EVs.
  - In 1990, California Air Resource Board (CARB) established rules that 2 % of all vehicles sold in California in 1998 should be ZEV (zero emission vehicles) and it should be 10 % by 2003.

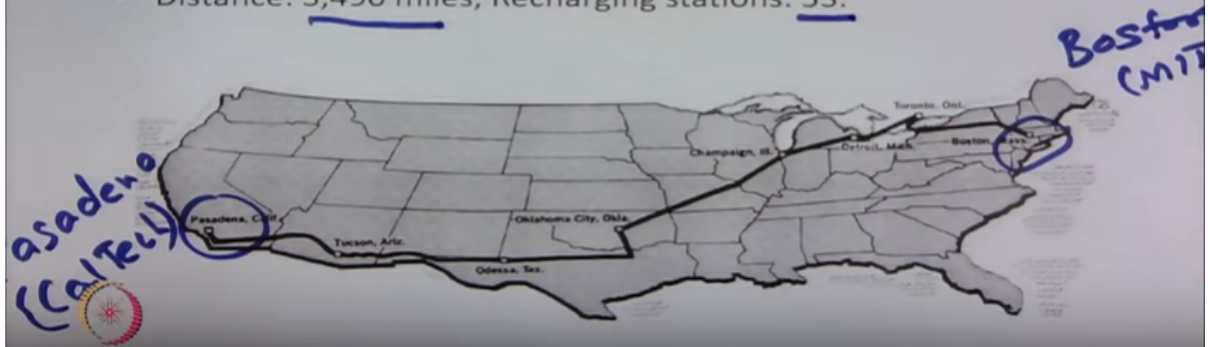
So after a gap of around 40 years', again there was a, resurgence, in the evolution of EVs. There were few developments at that time, which led to this. First was, there was a oil shortage in Arabian countries and Global countries were looking at possibility of alternate, energy resources. Secondly, by 1950s onwards, lot of cities like, London and California, have seen worst kind of smog. And this has pushed the governments, to bring strict, rules and regulations, which can enable governments to take decision, in development of EV technologies and make it feasible for commercial deployment. There is a famous regulation, which is known as, 'CARB', which is, 'California Air Resources Board'. So the regulation is very famous in EV domain. Because, this was the regulation, which has led a serious rethink, in the development of EV. So the rule says that, 2% of all vehicles to be sold in California, in, by 1998, should be, Zero Emission Type and it should be 10% by 2003.

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## Historical Background: Phase-2

In 1968, "Great Electric Car Race" was organized.

- Between Boston (MIT) and Pasadena (Caltech).
- Distance: 3,490 miles, Recharging stations: 53.



There was also a great push, in academic circles, to promote the research and development, in EV area. One of them was the organisation of, 'Great Electrical Car Race'. That was organised in 1968. So this race is between, Boston near MIT, to Pasadena, near California Institute of Technology, which is known as, 'Caltech'. So the challenge was this, though the universities, will develop their own EVs and the EVs developed by this universities, will travel from, MIT to Pasadena and Pasadena to MIT, covering a distance of, around 3400 miles. And they were able to recharge their EVs, by 53 intermediate, recharging stations. So this was one of the important event, which led to development EVs, in many universities in US. And it helped the industry in US, to come up with commercial EVs.

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## Historical Background: Phase-2

- Many automakers especially in US, Japan and Europe started development of EVs.
  - In US, General Motors, Ford, Chrysler, US Electricar and Solectria etc.
  - In Japan, Toyota, Nissan, Honda, Mazda, Daihatsu, Mitsubishi, Suzuki, Isuzu, Subara etc.
  - In Europe, PSA Peugeot, Renault, BMW, Mercedes-Benz, Audi, Volvo, Opel, Volkswagen, Fiat, Bedford etc.
- GM built number of experimental EVs, such as Electrovan in 1966, Electrovan in 1968, Electrovette in 1979 etc.
  - SCR based SE DC Motor, with Ni-Zn Batteries, 60 miles/Hr, 80 Km range.

Due to strict regulations and the opportunity of getting subsidies, many auto makers in US, Japan and Europe, started development of EVs. So we have listed out some of the main companies like, General Motors, Ford and Chrysler in US. In Japan, almost all the companies like, Toyota, Nissan, Honda, Mitsubishi, Suzuki, led the way for the development of EVs. In Europe, Peugeot, Renault, BMW,

Mercedes, Audi, Volvo, Volkswagen, most of these companies have launched their own EVs in the near future. So General Motors were able to launch, few of their experimental EVs, such as, Electrovair in 1966, Electrován in 1968, Electrovette in 1979. So these technologies were based on conventional separately as a DC motor, with a SCR based inverters. Since the conventional, IGBT based, VSIs were not available at that time.

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Introduction to EV

## Historical Background: Phase-2

- Ford EV projects resulted in Fiesta EV, Escort EV, Aerostar, Ecostar etc in 1970s.
- Nissan development work includes EV-4, EV-Resort, President EV and Cedric-EV in 1970s/80s.
- Toyota produced series in EVs named EV-10 to EV-40 in 1980s.
- Fiat experimental EVs were X1/23, Y10 in 1980s and Elettra in 90s.
- BMW produced early convertibles such as E30E, E36E in early 90s and E1 in mid 90s.

The other companies, like, Ford has launched some of its EVs, like, Fiesta EV, Escort EV, and etc. Nissan, Toyota, Fiat and BMW have launched their own EVs, by late, 1980s and 90s.

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Introduction to EV

## Historical Background: Phase-3

- Popular EVs in 1990s/Early 2000
  - GM EV1 ✓ [100 KW, IM, VRLA, 0-100 km/hr in 9 sec, 144 Km]
  - Nissan Altera EV [62 KW, PMSM, Co-Li, 120 km/hr, 192 Km]
  - NIES- Luciole [72 KW, In-Wheel PMSM, VRLA, 130 Km/Hr, Solar]
  - HKU-U2001 [45 KW, PMSM, Ni Cd, 110 Km/Hr, 176 Km]
  - Reva Etc. [13 KW, SE DC, VRLA, 65 Km/Hr, 80 Km]
- Popular HEVs in 1990s ✓
  - Toyota Prius ✓ [52 KW ICE, 33 KW PMSM, Ni mH, 160 Km/hr]
  - Honda Insight Etc. [50 KW ICE, 10 KW PMSM, Ni mH, 26-30 Km/L]
- Popular FCEV in 1990s/Early 2000
  - Ford P2000 ✓
  - Daimler-Benz NECAR-3 Etc. ✓

So by late 90s, many companies were able to launch their EVs. And which were, you can say, a very good vehicles, in terms of performance and efficiency. There is a vehicle names, named as, 'GM EV1'. So, it used 100 Kilo watt, induction machine, with lead acid battery and it is able to achieve, 100 kms/hr, within 9 seconds. And it has a range of, 144 kilometres. This vehicle has got a very good

name, in terms of design and it was almost certain that, EV will pick up from there. Nissan has launched its EV, named as, 'Altera EV', which is based on 62 kilo watt, PMSM drive and it was to go up to 120 kilometre, per hour, with 192 kilometre range. This institute in Japan, which is known as, 'National Institute of Environmental Studies', short form NIES, which went ahead with very high performance, EVs. Which are very complex to build and operate. So this works on a principle of, In-Wheel drives. Which means, separate motors are used to control, separate wheels of the vehicle. Is very complex, but it has taken the EVs to a next level. The performance, better than IC engine based vehicles, in terms of, operation. Another university, known as, 'Hong Kong University', has launched a similar vehicle, named as, 'U2001', this similar performance. In India, electric car, called, 'Reva', was launched in 2002, which was a low power urban car, based on separately SE DC machine. With a top speed of 65 km/hour, with a range of, 80 kms. The hybrid electric vehicles, also became popular in 1990s. Some of them were, Toyota Prius, all of us know and Honda Insight. So they were launched within a span of 2, 3 years. So both were based on, high engine capacity and low power electric motor. So you can say, it is a engine heavy, hybrid electric vehicle. There were some popular, fuel cell electric vehicles also launched at that time. So one was from Ford and another from, Daimler-Benz. So this vehicle used, hydrogen as fuel.

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Introduction to EV

## Historical Background: Phase-3

- Current Popular EVs
  - Tesla Roadstar (2007), Model-S(2012), Model-X(2015), Model-3(2017)
  - Nissan Leaf ✓
  - Chevy Bolt ✓
  - BMW i3 Etc.
- Current Popular HEVs are mostly PHEVs variants. ✓
  - Honda Accord hybrid
  - Toyota Camry, Prius hybrid
  - Ford Fusion hybrid
  - Lexus RX 450h
  - Volvo XC60 T8
  - BMW 740e xDrive Etc.

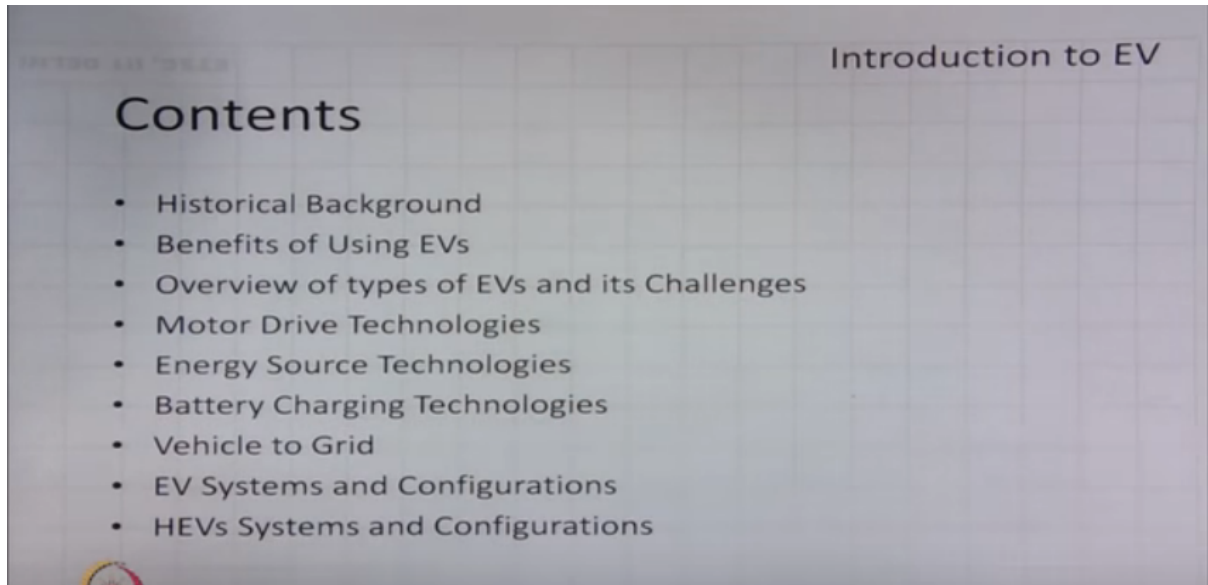
} Luxury Sedans.  
 ICE low rating      Motor High rating

In the current scenario, the EVs are extremely popular and they are able to compete with conventional IC engines, in terms of performance. The famous models of Tesla, is known to everyone. So they have launched 4 vehicles, till now, starting with, Roadstar. And now, recently they have launched, Model 3, which is extremely, high performance, EV. Product by Nissan, which is called, 'Nissan Leaf', is also extremely popular, globally. Similarly, the name of Chevy Bolt, is a household name, Europe. The other products, such as, BMW i3, which is also popular. Chevy's are also popular, but now, all are PHEV type. Means, pluggin, electric, vehicles. Which means, it is electric motor heavy, HEV. So IC engine is, low power device, primarily used to recharge the battery for long range requirements. So some of the popular products are, Honda Accord hybrid, Toyota, Toyota Camry, Toyota Prius hybrid, Ford Fusion hybrid. There are also luxury version of them, which are costly and meant for high segment, like, Lexus RX, Volvo T8 and BMW xDrive. So these are called, 'Luxury



Sedans'. So the internal parameters of these vehicles, will be discussed, as we go along in the presentation. And we will see, how these EVs and HEVs are configured, internally. So this is the end of our, first topic, introduction to EV, which is historical background.

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And we will go to, next topic of this sub-session, which is, benefits of using EVs, compared to, other modes of transport. And, thank you.