Renewable Energy and Electric Vehicles

About:

Renewable energy is one of the fastest growing industries on the planet, with billions of dollars invested each year to meet international energy sustainability goals. The focus is to provide a solid foundation for understanding and deploying important renewable energy technologies such as wind and solar. In addition to a good understanding of important energy storage technologies such as pumped hydro, batteries, and hydrogen will help in the long run.

But, any understanding of renewable energy requires vocabulary, principles, and tools like– We first define "energy." What is it? Where does it come from? How is it measured? What are its rules? What is electricity? How is it measured? How can renewable resources be used to generate electricity? Upon detailed study, you will have a solid grounding in the underlying concepts required to understand the promise and challenges of renewable energy technologies.

An electric vehicle (EV) is one that operates on an electric motor, instead of an internal-combustion engine that generates power by burning a mixture of fuel and gases. Therefore, such a vehicle is seen as a possible replacement for current-generation automobiles, in order to address the issue of rising pollution, global warming, depleting

natural resources, etc. Though the concept of electric vehicles has been around for a long time, it has drawn a considerable amount of interest in the past decade amid a rising carbon footprint and other environmental impacts of fuel-based vehicles.

Electric vehicles have low running costs as they have less moving parts for maintenance and are also very environmentally friendly as they use little or no fossil fuels (petrol or diesel). While some EVs used lead acid or nickel metal hydride batteries, the standard for modern battery electric vehicles is now considered to be lithium ion batteries as they have a greater longevity and are excellent at retaining energy, with a self discharge rate of just 5% per month. Despite this improved efficiency, there are still challenges and hence this is one of the topics combined with Renewable Energy to help take up the innovation in the right direction.

Pre-Requisites:

Basic Physics

Understanding of Electric Current and relevant concepts

Topics Involved:

- Energy & electricity

- Battery Technologies

- Renewable Energy Sources

- Solar Panels

- Electric Vehicles & automobiles

- Motors & Electrical Drawings

- Transformers

. Battery Management System

Syllabus:

Overview:

An Electric Vehicle is a type of vehicle that is powered on Electric Power. EVs operate on Electric Motor instead of an Internal Combustion Engine i.e a traditional petrol/diesel engine. This Electric Motor is powered by Rechargeable batteries that can be charged by common household electricity. There are two types of Electric Vehicles. Those are a) Hybrid and b) Pure Electric.

Hybrid Electric Vehicles (HEVs) are powered by an Internal Combustion Engine in combination with one or more electric motors that use energy stored in batteries. This type of mechanism helps increase the Fuel Economy of the vehicle. HEVs are further classified into a) Fully Hybrid - Whose batteries are recharged using the generator through the Internal Combustion Engine. b) Plug-In Hybrid - Whose batteries can be

recharged by plugging a charging cable to an external power source in addition to its internally by its on-board Internal Combustion Engine powered Generator.

To learn more about Hybrid Electric Vehicles (HEVs) you may refer to the below links:

https://www.aathornton.com/hybrid-vehicles-simple-guide/

https://afdc.energy.gov/vehicles/electric_basics_hev.html

https://www.youtube.com/watch?v=o6lPDOf-wEs

Pure Electric Vehicles which are most commonly referred to as EVs are the ones whose powertrain(That provides power to move the wheels) consists of Electric Motor only.The main parts of a Fully/Pure/All Electric Vehicle are Battery,Control Unit and ElectricMotor.
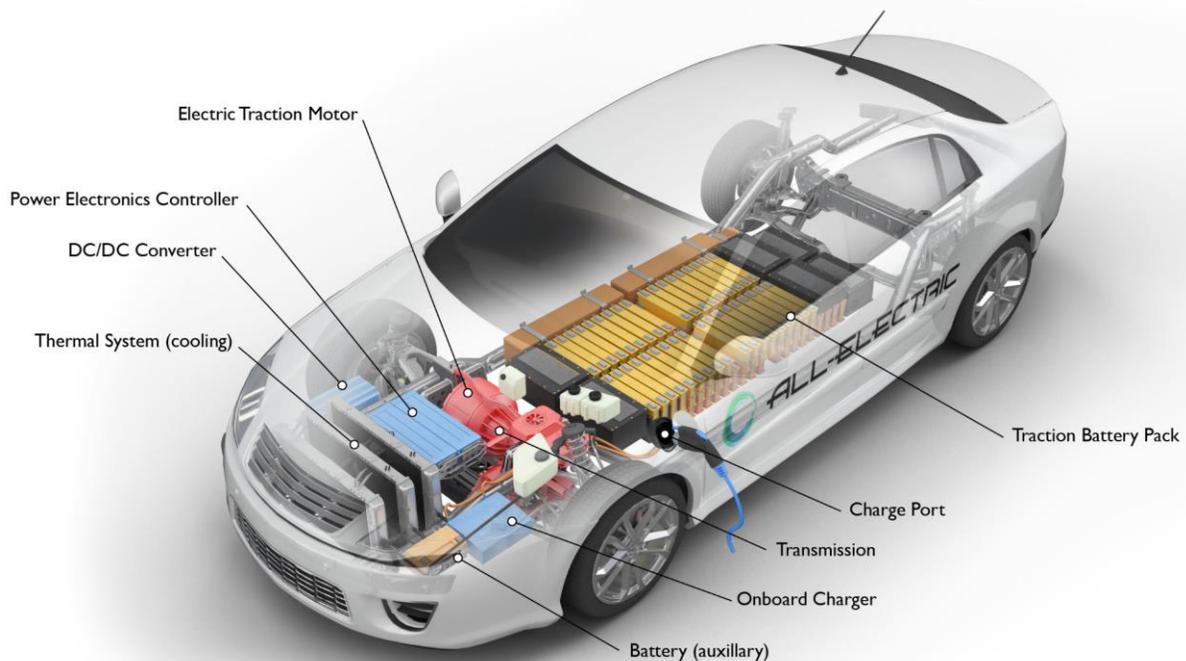
Battery

The fundamental piece of any Electric Vehicle is its battery. A Battery is a source of Electrical Power that consists of Electrochemical Cells whose chemical reactions are converted into electrical energy. It consists of Positive Terminal (Cathode) , Negative Terminal (Anode) and an Electrolyte.

To learn more about the basics of batteries, refer to the below links:

https://learn.sparkfun.com/tutorials/what-is-a-battery/all

https://www.engineersgarage.com/introduction-batteries-their-types/

https://www.allaboutcircuits.com/technical-articles/introduction-to-electric-vehicle-battery-systems/

Some of the most commonly used types of batteries in EVs are Lead-Acid, Lithium-Ion and Nickel-Metal Hydride batteries.

To know more about the types of batteries used in EVs, refer to the below links:

https://afdc.energy.gov/vehicles/electric_batteries.html

https://www.energysage.com/electric-vehicles/101/how-do-electric-car-batteries-work/

https://www.renaultgroup.com/en/news-on-air/news/the-different-types-of-electric-car-batteries/

Electric Motor

A motor is an electrical device that converts electrical energy to mechanical. It works on the principle of Fleming's Left Hand Rule

To learn more about the basics and working of Electric Motors, you may refer to the below links:

https://www.theengineeringprojects.com/2020/09/introduction-to-electric-motors.html

https://www.yaskawa-global.com/product/mc/about-motor

There are different types of motors that are used in EVs.

To learn more about the types of motors refer to the links below:

https://circuitdigest.com/article/different-types-of-motors-used-in-electric-vehicles-ev

https://gomechanic.in/blog/electric-vehicles-types-explained/

The below article has a detailed explanation of different components in EVs.

https://news.hyundaimotorgroup.com/Article/Understanding-EV-Components

Control Unit

The control unit or controller is the brain of the Electric Vehicle.The basic function of a controller is to control the vehicle's speed and acceleration and to coordinate between its internal and external components and peripherals.

Here's a block diagram of an EV controller.
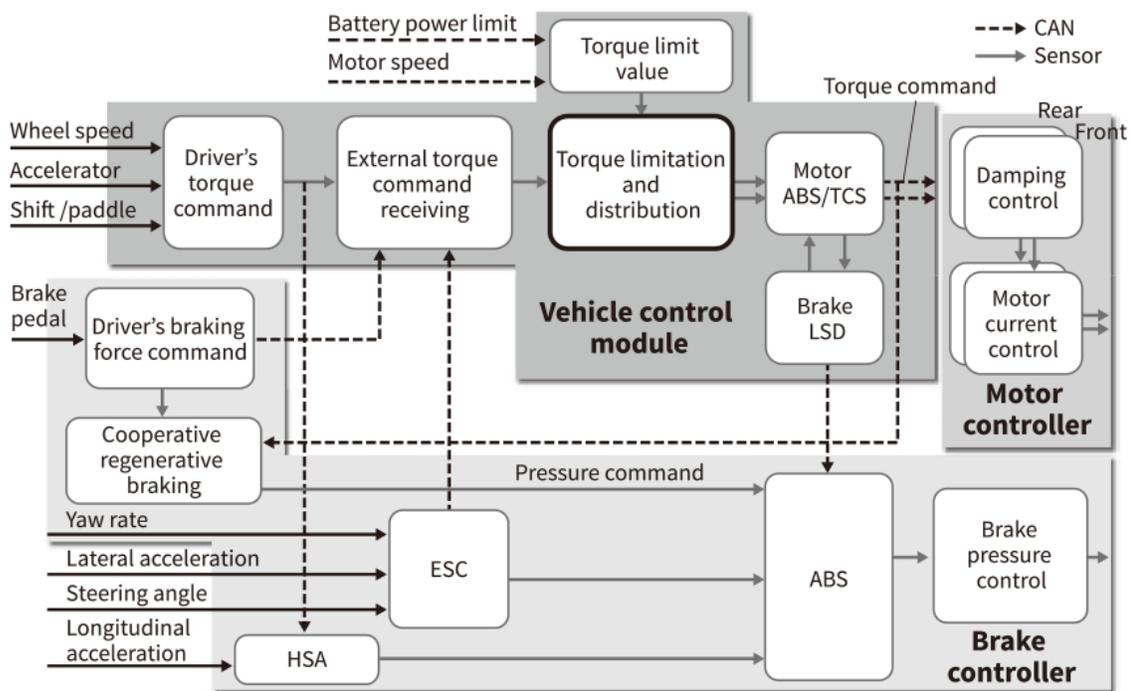
CAN: controller area network   LSD: limited-slip differential   ABS: anti-lock brake system
TCS: traction control system   ESC: electronic stability control   HAS: hill start assist

Image Credits: hitachi.com

The below document has a detailed overview of control systems in Electric Vehicles.

Note: The concepts in this document are very fundamental and deep that a beginner might not be able to follow up. Use this as a reference when you are building complex systems.

https://cdn.intechopen.com/pdfs/12061/InTech-Control_of_electric_vehicle.pdf

Level 1:

For a beginner, it might seem complicated to understand an actual Electric Vehicle. In order to make it much simpler to understand the basic functionality of an EV, it is necessary to understand things at a much smaller level and you can do that by building a miniature Electric Vehicle using hobbyist electronic components.

Level 1 Milestones:

- Build a miniature electric vehicle using basic components
- Interfacing Sensors for intelligent control
- Introducing communication protocols to the system

Like we studied earlier, the main parts of an EV are Battery,Controller and an Electric Motor.

Let's look at the things that we are going to use to build a miniature EV.

Electric Motor:

For hobbyist use, the most commonly used Electric Motors are 3V Toy DC Motor and DC Geared Motor.

Standard DC Motor   *DC Gear Motor*

The difference is that a DC Gear motor provides more torque compared to a standard DC Motor. That is when you want the motor to pull weights, use DC Gear Motor. To build a mini EV we'll be using a DC Gear Motor.

Interfacing & Control of a DC Motor

A DC Motor uses Direct Current (DC) to convert Electrical Energy into Mechanical Energy(Rotation).
Certain characteristics like Speed, Direction of Rotation etc of a Motor can be controlled using a Microcontroller.

Most of the microcontrollers operate at low voltages and require a small amount of current to operate while the motors require a relatively higher current.

To solve this problem, a Motor Driver Circuit can be used along with the microcontroller. Some of the most commonly used Motor Driver ICs are L293D and L298N. They are also available in the form of Modules/Boards to ease the process of making connections.

Using a Microcontroller, the following will be achieved:

1. Controlling the Speed of Rotation
2. Controlling the Direction of Rotation

Refer to know more about Interfacing DC Motors with L293D:

https://lastminuteengineers.com/l293d-dc-motor-arduino-tutorial/

Speed Control

Using a Potentiometer.

https://techexplorations.com/guides/arduino/motors/dc-motor-speed-direction-lm298n-arduino-project2/

Direction Control

Using a Switch/Push Button or any Two State input element.

https://www.instructables.com/Arduino-DC-motor-speed-and-direction-L293D/

The following functionalities of an Electric Vehicle is achieved:

1. Moving a vehicle in Forward or Reverse.

2. Ability to change the speed of the Vehicle.

Vehicle Turn/ Steering

There are two ways you can achieve a turn in a mini EV.

a) Swing Turn

b) Point or Sharp Turn

During the swing turn, either the left or right wheel is powered while the other wheel is

not. When this happens, the vehicle moves in a curved path.

During the point turn, the two wheels are powered to rotate in the opposite direction.

When this happens, the vehicle achieves a sharp turn at a single point.

This type of turn is useful when the vehicle moves in a path that requires a 90 degree

turn.

To learn more about interfacing motors, refer to the below link:

https://techexplorations.com/guides/arduino/motors/dc-motor-lm298n-arduino-project1/

https://www.allaboutcircuits.com/projects/control-a-motor-with-an-arduino/

Interfacing Sensors

A sensor is **a device that receives a signal or stimulus, and responds to the stimulus in** the form of an electrical signal.

Introducing sensors in a vehicle will help achieve intelligent control during numerous situations.

To learn more about interfacing sensors, refer to the below link:

https://create.arduino.cc/projecthub/JANAK13/using-sensors-with-arduino-eab1ec

Solar Panels

A Solar Panel or sometimes referred to as Photovoltaic Module is a device that produces flow of electricity under sunlight.

It is made up of several Photovoltaic Cells mounted in a framework.

To learn more about solar panels, refer to the below links:

https://energyeducation.ca/encyclopedia/Solar_panel

https://www.thegreenage.co.uk/tech/types-of-solar-panel/

TASKS/ PROJECTS

Task Number	Project Name	Components Required	Link for Reference
1	Speed Control of a Motor	Motor, Potentiometer & Motor Driver	https://techexplorations.com/guides/arduino/motors/dc-motor-speed-direction-lm298n-arduino-project2/
2	Direction Control of a Motor	Motor, Push Button, Motor Driver	https://www.instructables.com/Arduino-DC-motor-speed-and-direction-L293D/
3	Point Turn of a Vehicle	2 Motors, Motor Driver	https://www.instructables.com/How-to-Use-the-L293D-Motor-Driver-With-Arduino/
4	Swing Turn of a Vehicle	2 Motors, Motor Driver	Refer the link for Point Turn
5	Line Following Car	2 Motors, 2 IR Sensor Modules	https://create.arduino.cc/projecthub/saher-iqbal/line-follower-robot-36516b
6	Obstacle Avoiding Vehicle	2 Motors+ Drivers,Ultrasonic Sensor	https://create.arduino.cc/projecthub/mindhe_aniket/obstacle-avoiding-robot-765e39
7	Bluetooth Controlled Car	Motors+Drivers, Bluetooth Module(HC 05)	https://create.arduino.cc/projecthub/samanfern/bluetooth-

			controlled-car-d5d9ca
8	IR Remote Controlled Vehicle	Motors+ Drivers, IR Receiver Module, IR Transmitter(TV Remote)	https://create.arduino.cc/projecthub/comptek4/ir-remote-control-car-fcb8a5
9	Powering an Arduino from a Solar Panel	Solar Panel,Voltage Regulator & few capacitors	https://www.deviceplus.com/arduino/entry025/
10	Solar Tracker	Servo Motor and few basic components	https://create.arduino.cc/projecthub/336271/arduino-solar-tracker-41ef82

Note: The above projects are performed using a microcontroller (preferably an Arduino) along with basic components like connecting wires,resistors etc.
Motor Drivers like L293D or L928N are some of the commonly used and are easy to interface.
The above projects can be built using a Kit that comes with a Chassis and Wheels.

Level 2:

Battery management system:

A Battery Management System (BMS) is an intelligent component of a battery pack responsible for advanced monitoring and management. It is the brain behind the battery and plays a critical role in its levels of safety, performance, charge rates, and longevity.

To learn more about BMS, refer to the below links:

https://www.einfochips.com/blog/understanding-the-role-of-bms-in-electric-vehicles/

https://evreporter.com/battery-management-system-for-electric-vehicles/

Build a BMS for a pure electric vehicle that monitors conditions like current, voltage, temperature etc.

Communication protocols used in automobiles: CAN bus

A **Controller Area Network** (**CAN bus**) is a robust vehicle bus standard designed to allow microcontrollers and devices to communicate with each other's applications without a host computer. Let us try to understand and simulate a CAN bus messaging system using the microcontrollers available to us.

For a deeper understanding of the CAN protocol and why it is used extensively in the automobile industry, read the following document:

https://www.csselectronics.com/pages/can-bus-simple-intro-tutorial

We will try to build a project around the CAN bus using the arduino development board and the MCP2515 CAN module. Follow this tutorial to understand how to use CAN in the arduino environment

https://circuitdigest.com/microcontroller-projects/arduino-can-tutorial-interfacing-mcp2515-can-bus-module-with-arduino

Level 3:

You now have a good idea about the working of Electric Vehicles along with Interfacing different Sensors and elements.

Note: Whenever you are working on a project, try to maintain proper documentation about the things that worked and ways that failed.

Assessment:

Level 1:

Upon completion of every task/project, you are required to
1. Make a Video of the working prototype
2. Create a detailed report of the project

Level 2:

Upon completion of every task/project, you are required to
1. Make a Video of the working prototype
2. Create a detailed report of the project
3. Conduct a seminar explaining what you learnt in each of the projects you did in this level

After successful submission of the report and completion of the seminar, you will be allowed to move to level 3.

Level 3:

Level 3 assessment will be on a case-by-case basis. Contact your coordinator for more details.

References:

Useful Links:

Courses:

- https://www.coursera.org/learn/renewable-energy-technology-fundamentals

- https://www.coursera.org/learn/solar-energy-basics

- https://www.coursera.org/learn/solar-cells

- https://www.coursera.org/learn/battery-management-systems

- https://www.edx.org/course/electric-cars-introduction

- https://www.edx.org/course/electric-cars-technology

- https://www.coursera.org/learn/intro-self-driving-cars

- https://www.coursera.org/learn/power-electronics

- https://www.coursera.org/specializations/algorithms-for-battery-management-systems

- https://www.edx.org/course/batteries-fuel-cells-and-their-role-in-modern-so-2

- https://www.edx.org/course/sustainable-energy-design-a-renewable-future

- https://www.edx.org/course/smart-grids-the-basics

- https://www.edx.org/course/distribution-and-control-of-heat-cold-and-air-flows-in-buildings

Notes: