The internal combustion engine

Crude oil discovered

China 2000BC

First refined in 1846 when Abraham Gessner of Nova Scotia, Canada devised a process to produce kerosene from coal. Shortly thereafter, in 1854, Ignacy Lukasiewicz began producing kerosene from hand-dug oil wells near the town of Krosno, Poland. However, crude oil was first refined into petroleum with the successful drilling of the first oil wells in Ontario, Canada, in 1858 and in Titusville, Pennsylvania, U.S., in 1859.

First internal combustion engine

- The first commercially successful internal combustion engine was created by Étienne Lenoir around 1860, and the first modern internal combustion engine, known as the Otto engine, was created in 1876 by Nicolaus Otto.
- There are two main types of fuel.
  - Petrol
  - Diesel

Types of engine

- There are two main types of internal combustion engine
  - 4 Stroke
  - 2 Stroke
  - Rotary

  - 2 Stroke
  - A **two-stroke** (or **two-stroke cycle**) **engine** is a type of internal combustion engine that completes a power cycle with two strokes of the piston (one up and one down movement) in one revolution of the crankshaft. In a two-stroke engine, the end of the combustion stroke and the beginning of the compression stroke happen simultaneously, with the fuel and exhaust (or scavenging) functions occurring at the same time.

Types of engine

- A **four-stroke engine** is an internal combustion engine in which the piston completes four separate strokes while turning the crankshaft. A stroke refers to the full travel of the piston along the cylinder in either direction. The four separate strokes are termed:

1. **Intake**: Also known as induction or suction. This stroke of the piston begins at top dead centre (T.D.C.) and ends at bottom dead centre (B.D.C.). In this stroke the intake valve must be in the open position while the piston pulls an air-fuel mixture into the cylinder by producing a partial vacuum (negative pressure) in the cylinder through its downward motion.
2. **Compression**: This stroke begins at B.D.C, or just at the end of the suction stroke, and ends at T.D.C. In this stroke the piston compresses the air-fuel mixture in preparation for ignition during the power stroke (below). Both the intake and exhaust valves are closed during this stage.
3. **Combustion**: Also known as power or ignition. This is the start of the second revolution of the four stroke cycle. At this point the crankshaft has completed a full 360 degree revolution. While the piston is at T.D.C. (the end of the compression stroke) the compressed air-fuel mixture is ignited by a spark plug (in a gasoline engine) or by heat generated by high compression (diesel engines), forcefully returning the piston to B.D.C. This stroke produces mechanical work from the engine to turn the crankshaft.
4. **Exhaust**: Also known as outlet. During the *exhaust* stroke, the piston, once again, returns from B.D.C. to T.D.C. while the exhaust valve is open. This action expels the spent air-fuel mixture through the exhaust port.

Rotary Engine

- Although not common these have been fitted to a few production cars.
- They use a rotor instead of the typical engine components.

Main Engine Parts

- Internal combustion engines are complex in design and have many moving parts. The main parts are:
- Main (Cylinder) Block
- Crankshaft
- Piston
- Cylinder head
- Valves
- Camshaft
- Fuel delivery system
- Exhaust gas system
- Control System
- Cooling System
- Ancillary parts

Main Cylinder Block

The picture opposite has 4 cylinders.

Engines can have from 1 cylinder (lawn mowers) to typical 16 as a maximum.

Blocks can have the cylinders in a straight line as in the image or in a vee shape as per the model. There are also some blocks that have them opposed.

Main Cylinder Block

- This is the main part on the engine and can be commonly made from either cast iron or aluminum.
- This houses the pistons (complete with connecting rods) and crankshaft.
- In early designed cars, the cylinder block could have housed camshaft and valves. However as design and technology have progressed these have been moved to the cylinder head.
- These are typically made in a process called casting when molten metal is poured into a mold. This allows for oil and water ways to be incorporated.

Main Cylinder block

- Once the casting is cooled then the “block” is machined to a high precision.
- If the “block” is made from aluminum, then a steel linear is used to reduce the wear from the pistons.

Crankshaft and Pistons

The picture above shows a 6 cylinder crankshaft and pistons.

The Pistons are connected to the crankshaft with a connecting rod. Each end of the connecting rod will have bearing. The end at the piston is called a small end, the end on the crankshaft is called a big end.

The crankshaft is normally made from a forgings (big press). The pistons are normally made from aluminum and contact “rings” to aid compression and control oil.

Cylinder Heads

- The cylinder head sits on top of the engine and commonly houses the valves and camshaft.
- A special gasket sits between the cylinder head and the cylinder block.
- Bolted to the cylinder will be the inlet and exhaust manifolds. In petrol engines the spark plugs will be fitted to the head.

Valves

- The valves allow for the air/fuel mixture to enter the engine and exhaust gases to leave.
- Valves will be ground (lapped) into the cylinder head to achieve an air tight seal.

Camshaft

- The camshaft or camshafts control the opening and closing of the valve and are driven by the crankshaft via belts or chains.
- In some modern cars, the timing between the crankshaft and camshaft can be mechanically varied to alter the timing of the intake and exhaust gases.

Fuel delivery

- Carburetors

- Fuel Injection

Fuel Systems

- Carburetor
  - Until the mid 1980's petrol engines used a carburetor to 'inject' fuel into the engine. This is bolted to the inlet manifold and mixed a spay of fuel with the incoming air to be passed into the cylinders ready for ignition. On some cars there were multiple carburetors to increase the amount of fuel/air delivered to the engine thus increasing power.
  - Multiple setups are difficult to balance in order to achieve an even flow of mixture to the engine.

Fuel Systems

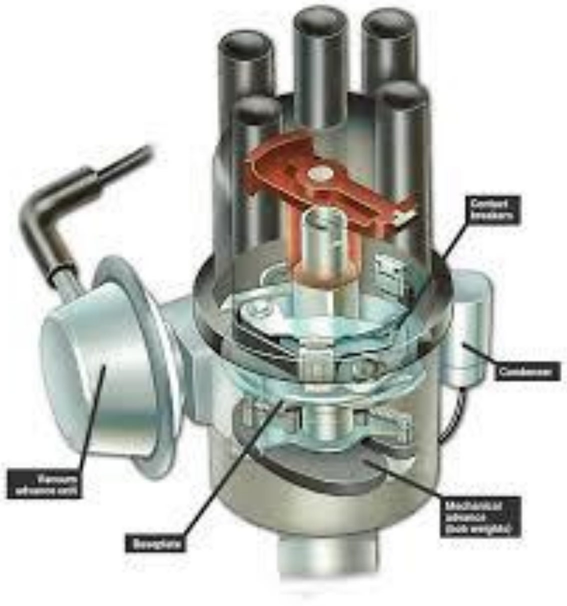
- Fuel injection
  - Mechanical
    - Older diesel engines had mechanical fuel injection systems driven by pumps connected to the engine in a similar way to the camshaft. The difficulty with this system is stopping the engine. This was typically done via a “decompression” valve in the engine to stop the combustion process.
  - Electrical
    - Most new cars fitted with petrol/diesel engines have electrical fuel injection systems. These are computer controlled to achieve the optimum fuel mixture and timing and can be easily stopped when the electrical is turned off.

Exhaust

- The exhaust manifold is usually made from cast iron or steel.
- Many performance engines have these gas flowed to allow better flow of gasses.

Control Systems

- Distributors



- Electronic Ignition /ECU

Distributors

- These are simple mechanical/ electrical devices for delivering a voltage to the spark plug at the correct time. Being simple, these are easily maintained but are not as accurate as the electronic system.

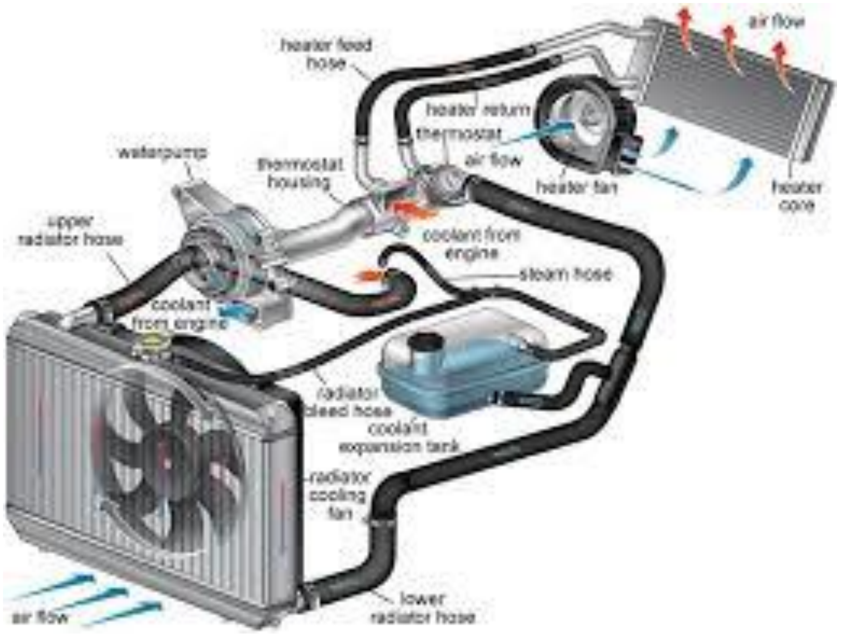
Electronic ignition and ECU

- Current cars use this system to control the timing of the spark (petrol engine) as well as emissions, timing of injection and engine monitoring.
- Whilst these are complex, problem solving is easy with the correct equipment.
- The downside is the complex system can be expensive to replace.

Cooling Systems

- Air Cooled

- Water cooled



Air Cooled

- Air cooled engines have the advantage of not having liquid travelling though the engine parts. These are typically used in motorbikes although VW and Porsche have used these to great effect in many vehicles including the Beetle.

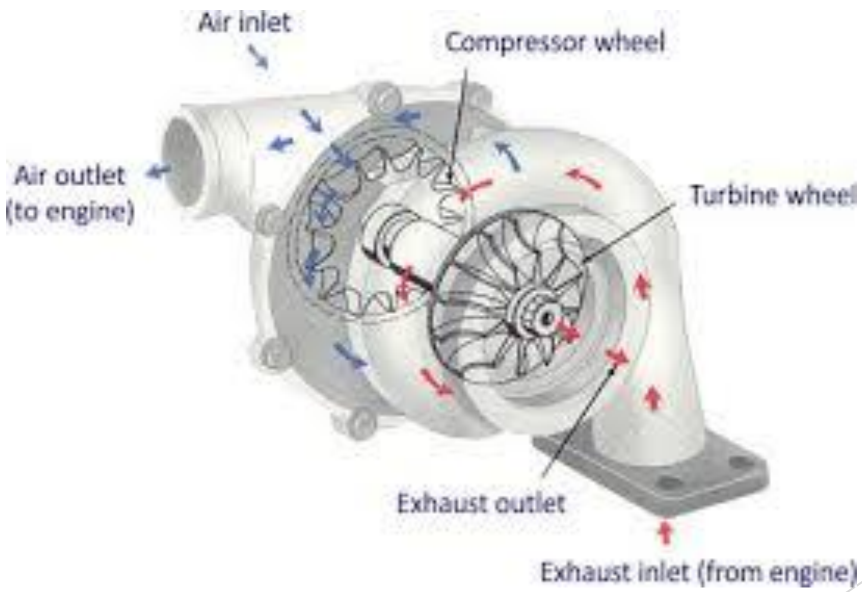
Liquid Cooled

- Liquid cooled engines use a coolant pumped around the engine to keep the temperature at the required level. This system is more complex than the air cooled but does allow for greater heat control.
- The radiator is typically cooled by a fan, either driven from the engine or electrically.

Ancillary parts – Forced induction

- Supercharging

- Turbo charging



Supercharge/ Turbo Charger

- Both systems are used to increase the amount of fuel/air mixture entering the engine.
  - Superchargers are driven via a mechanical drive from the engine.
  - Turbochargers use the exhaust gases to drive a turbine which is connected to another turbine on the intake.

Both systems have their drawbacks. Supercharges use some of the power from the engine to drive them and are not typically used on lower powered or smaller engines.

Turbochargers need to spin fast to become effective creating what is known as turbo lad, although modern systems are much better.

Summary

- The internal combustion engine has been used for over 100 years and uses fossil fuels. In today's world these are seen as not environmentally friendly. They are complex in design and manufacture and have many parts that can fail.
- However, for an old petrol head like me there is nothing like the sound of a V6 or V8 engine.

Electric Cars

The Future!!!


PANDORA



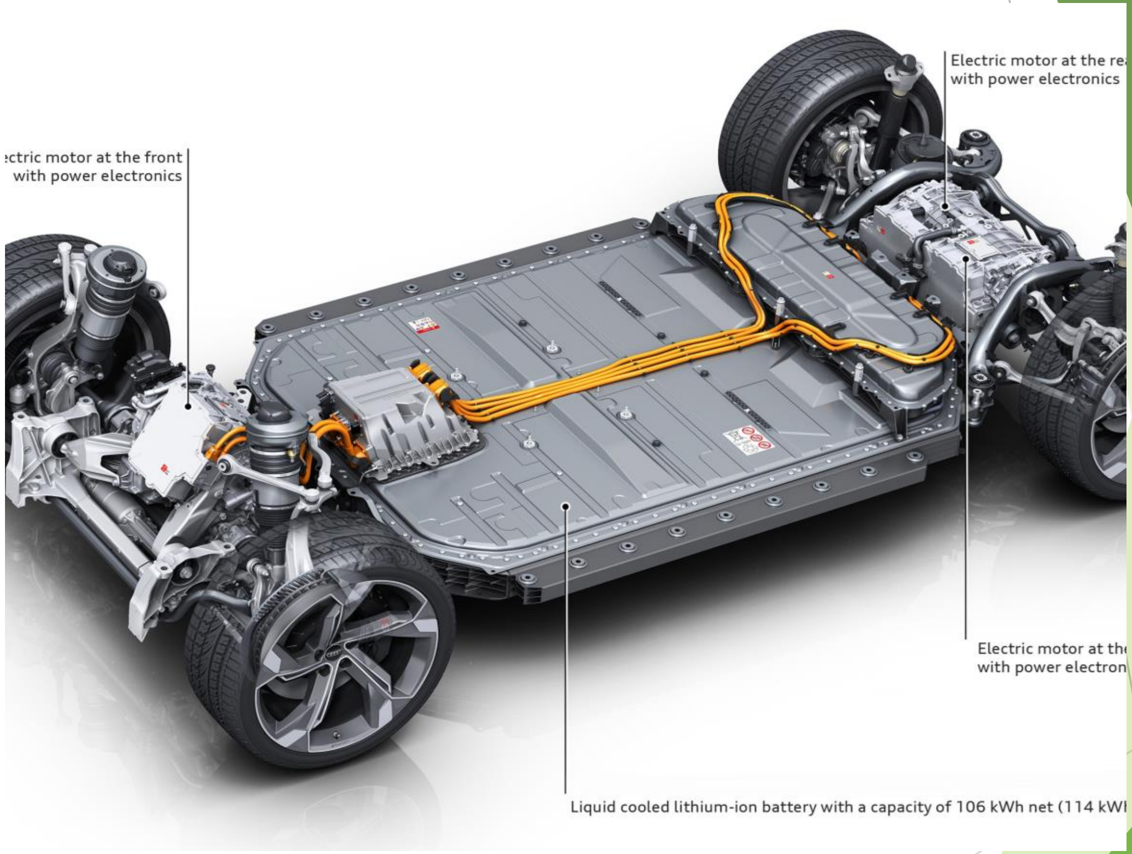

WP21 RMO


Battery Power and Hybrid

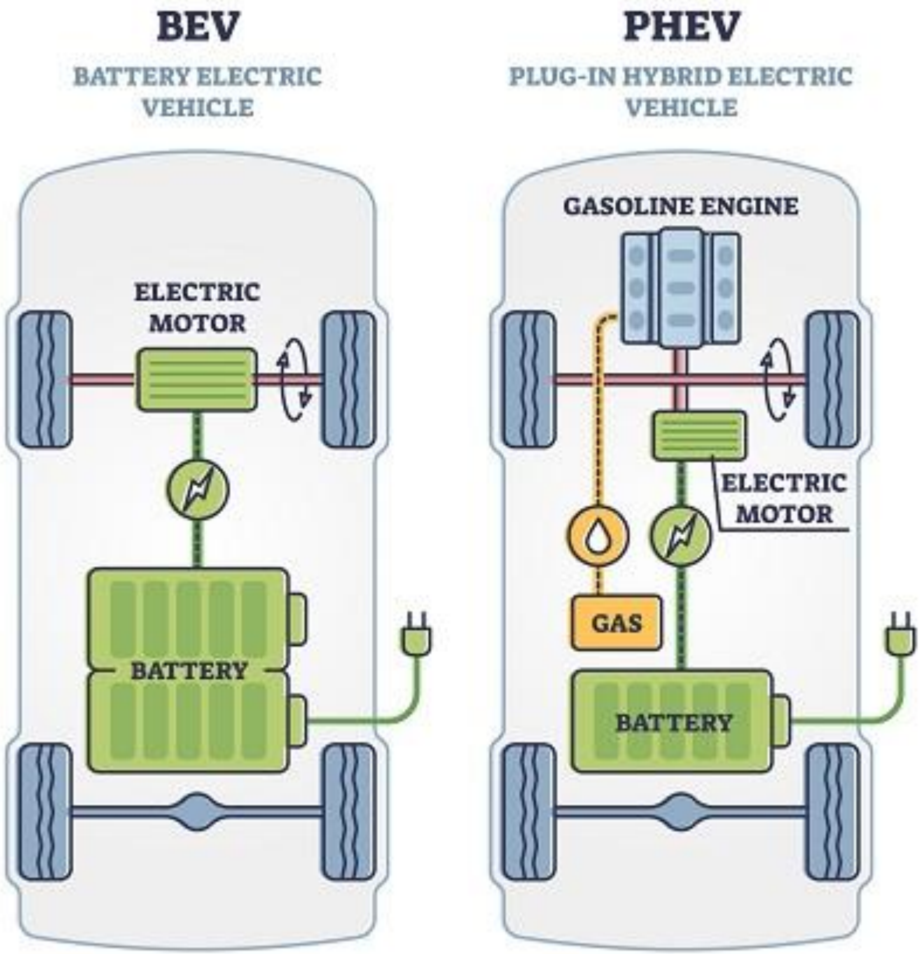
Battery Powered vehicles have been around for a few years, but it is only in the last 20 years that car manufacturers have taken the technology further.

Hybrids use a mixture of internal combustion engines and batteries to drive the vehicle, in some chases the internal combustion engine is used to charge the batteries and does not directly connect to the wheels.

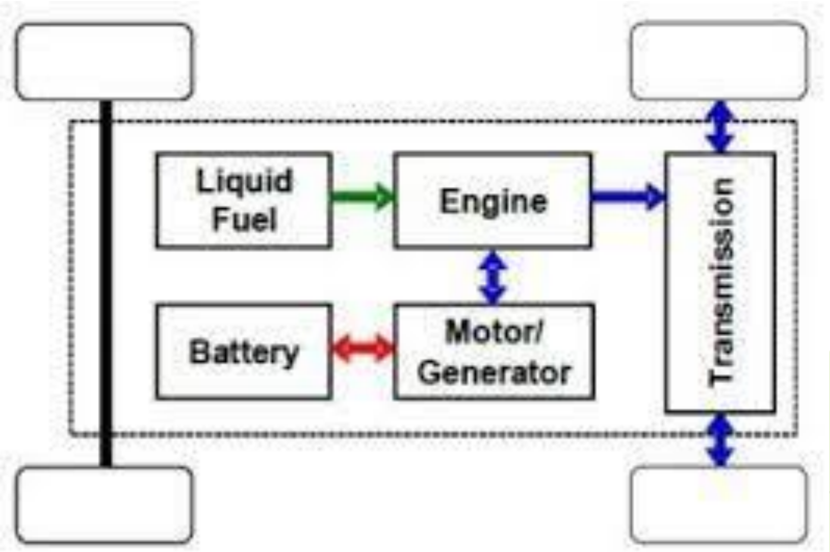
Pure battery vehicles will have an electric motor at each wheel or one motor per axle, or just one motor on one axle.



Battery and Hybrid

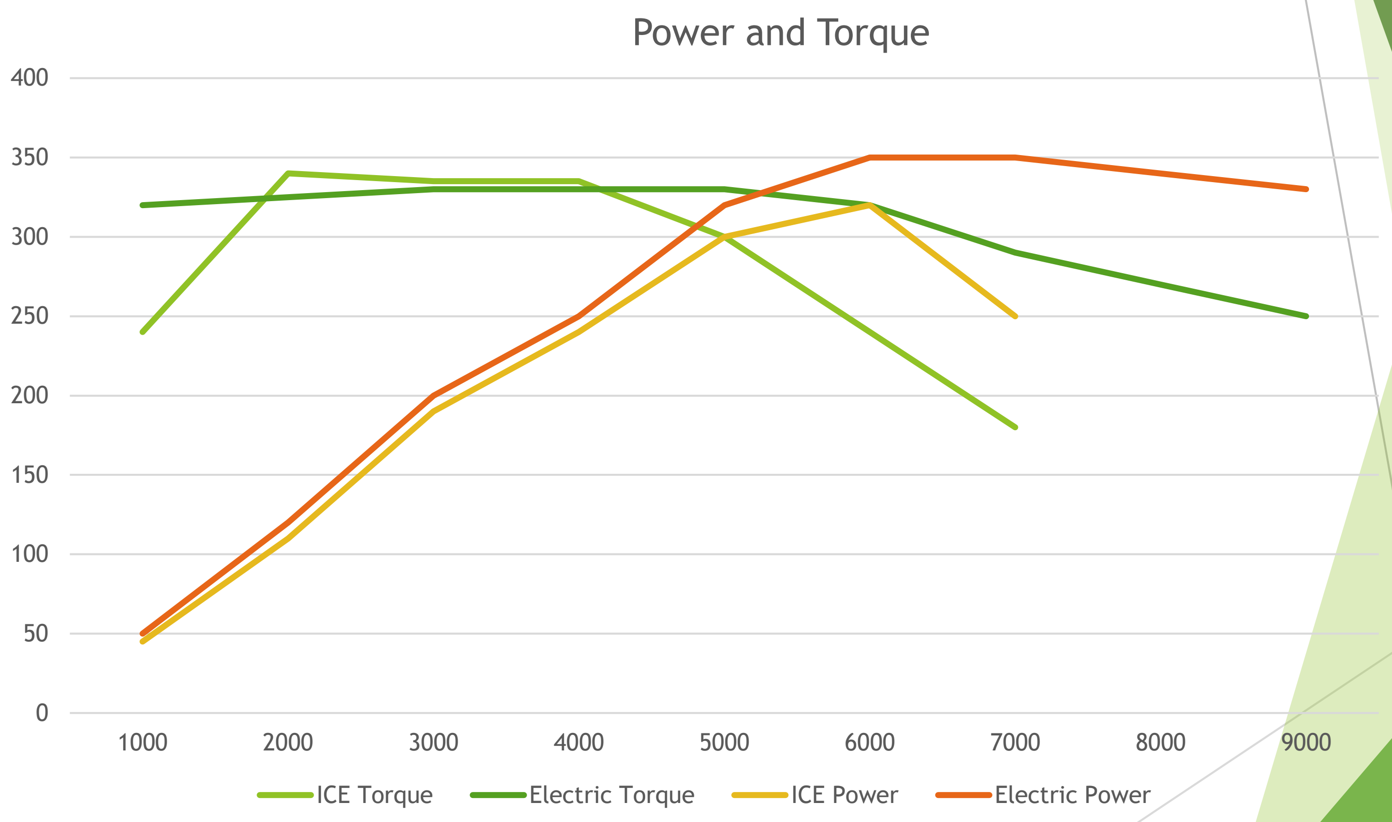


Self Charging Hybrid



Advantages

- Less use of fossil fuels.
- More efficient that internal combustion.
- Lower or Zero emissions.
- Lower noise levels.
- Lower or Zero Road Tax.
- ULEZ exempt.
- Greater power and torque.
- Less Moving parts.



Disadvantages

- Batteries costly to make, Lithium mines in China, shipped around the world.
- Less range than ICE.
- Not enough charging points.
- Length of time to charge.
- Fire risk greater.
- Vehicles more expensive.
- Battery life and replacement costs.

What Next - Hydrogen Power